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Parallax Machines

An Ethnography on Artificial Life in the Real World

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Abstract

Abstract (English)

This thesis is an anthropological tale about how a small group of artificial life researchers at the Ikegami Lab - an artificial life laboratory at the University of Tokyo, Japan headed by professor Takashi Ikegami – seek to fulfill their self-described mission to “construct artificial life in the real world”.

“Life” – the primary scientific object of artificial life, and that painfully imprecise concept that cuts across all of the living – is at the Ikegami Lab considered to be a constructive category, something, Ikegami and the lab members report, which is best *understood* by its material *construction* in artificial media, such as computer models, petri dishes or robots. Thus, it is by constructing new artificial systems, not from bits and pieces of biological materials or organic compounds, such as cells and genes, but from bits and pieces of silicone, rubber electronic circuitries, information, data, algorithms, ones and zeroes, that Ikegami and the lab members may better understand what life *is*. As an anthropologist of science and technology, I have spent about 7 months talking to and working with them.

Based on ethnographic fieldwork, this ethnography tracks a diverse set of techniques at work at the Ikegami Lab and how they seek to realize their aspiration to construct artificial life in the real world in order to better understand what life is. On an ethnographic journey through the Ikegami Lab, then, I show how these lab members think and talk about themselves and their work, but also how the lab is organized around Ikegami himself. Ikegami is a charismatic leader, I argue, whose personal qualities and style of leadership manifest as a sort of charismatic authority, by which he organizes and commands his lab. And as such, the social structure at the lab represents an emotional collectivization held together by an emotional bond with Ikegami. Thus, Ikegami, as a charismatic leader, offers to lab members his own set of worldviews, beliefs, principles, norms and values, which I call *Ikegamianism*, and to which the lab members adhere. And this is precisely, I want to show, what organizes and propels the Ikegami Lab into action, into constructing artificial life in the real world. To show what they mean by constructing artificial life in the real world, then, I introduce the concept of *parallax machines* to capture how Ikegamianism is given material expression through the artificial systems they make at the lab. Moreover, parallax machines, I further want to show, both materialize Ikegamianism *and* reflect what I call a parallax view of life that allows the artificial life researchers at the Ikegami Lab to straddle any meaningful distinction between “artificial life” and “biological life”. Parallax machines, in short, materialize *both* Ikegamianism, the set of values and beliefs springing from Ikegami’s charismatic authority, and a parallax view of life that connects, yet without resolving, indexical regimes that are normally indexed as separate: life may only be apprehended through a parallax view.

Abstract (Dansk/Danish)

Denne afhandling er et antropologisk indblik i, hvordan en lille gruppe forskere ved Ikegami Laboratoriet - et "kunstigt liv" (artificial life) laboratorium ved universitetet i Tokyo, Japan, ledet af professor Takashi Ikegami - søger at realisere deres mission om at "konstruere kunstigt liv i den virkelige verden".

Begrebet "liv" - det primære videnskabelige objekt for deres forskning og det smerteligt upræcise begreb, der skal forestille at være fælles for alle levende ting - betragtes blandt disse forskere som en kategori, der kan konstrueres materielt, noget, som bedst erkendes gennem dets materielle konstruktion i kunstige medier, såsom i computermodeller, petriskåle eller robotter. Det er således ved at konstruere nye kunstige systemer, ikke fra stykker af biologisk materiale eller organiske forbindelser, såsom celler og gener, men fra stykker af silikone, elektroniske gummikredsløb, information, data og algoritmer, at Ikegami og laboratiemedlemmerne forsøger at erhverve sig en bedre erkendelse af, hvad "liv" er. Som antropolog har jeg brugt tæt på 7 måneder på at tale og arbejde med dem.

Baseret på etnografisk feltarbejde undersøger jeg i denne etnografi en mangfoldighed af teknikker på Ikegami Laboratoriet og hvordan de søger, at realisere deres ambition om, at konstruere kunstigt liv i den virkelige verden for bedre at forstå, hvad "liv" er. På en etnografisk rejse gennem laboratoriet viser jeg, hvordan disse laboratiemedlemmer tænker og taler om sig selv og deres arbejde, men også hvordan laboratoriet er socialt organiseret omkring Ikegami. Ikegami er utvivlsomt en karismatisk leder, hvis personlige egenskaber og ledelsesstil manifesterer sig som en slags karismatisk autoritet, hvormed han organiserer og kommanderer sit laboratorium. Og som sådan, hævder jeg, repræsenterer den sociale struktur på laboratoriet en følelsesmæssig kollektivisering, som holdes sammen gennem et følelsesmæssigt bånd med Ikegami. Ikegami tilbyder, som karismatisk leder, medlemmerne af laboratoriet sit eget verdenssyn, sine egne overbevisninger, principper, normer og værdier, som jeg kalder Ikegamianisme, og det er netop, jeg vil vise, dette karismatiske lederskab, der organiserer og driver medlemmerne til handling. For at vise, hvad de mener med at konstruere kunstigt liv i den virkelige verden, introducerer jeg begrebet parallax-maskiner for at vise, hvordan Ikegamianisme får et materielt udtryk gennem de kunstige systemer, de laver på laboratoriet. Parallax-maskiner, vil jeg endvidere vise, både materialiserer Ikegamianisme og afspejler det, jeg kalder et parallax-livssyn, der gør det muligt for medlemmerne på Ikegami Lab at tøjle enhver meningsfuld forskel mellem "kunstigt liv" og "biologisk liv". Parallax-maskiner materialiserer kort sagt *både* Ikegamianisme, dvs. de værdier og overbevisninger, der udspringer af Ikegamis karismatiske autoritet, og et parallax-livssyn, der forbinder, men uden at løse, indeksregimer, der normalt indekseres som separate: "liv" kan kun pågribes gennem et parallax.

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My work as an anthropologist is beholden to – indeed unthinkable without – those about whom I write. I want to thank all the lab members at the Ikegami Lab, who offered me access to their work and to their lives, who were unselfish with their time and expertise, and who thoughtfully and indulgently answered my many questions. Professor Takashi Ikegami enthusiastically welcomed me into his lab and was happy to think reflexively and reflectively with me about his own scientific practice. My thanks go especially to him for allowing me into his lab. Among the lab members of the Ikegami Lab, including external collaborators, I also want to thank Nathaniel Virgo, Olaf Witkowski, Lana Sinapayen, Doi Itsuki, Atsushi Masumori, Mizuki Oka, Yasuhiro Hashimoto, Norihiro Maruyama, Hiroki Kojima, Yuma Kajihara, Julien Hubert, Ryuta Aoki.

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1

REAL ARTIFICIAL LIFE AT THE IKEGAMI LAB

Introduction: Larger than Life

Professor Takashi Ikegami is not only the leader, principal investigator and namesake of the Ikegami Lab – an artificial life laboratory consisting of about 15 lab members at the University of Tokyo - he is also larger than life. A veteran artificial life researcher, Ikegami has been in the field of artificial life for over 20 years. Yet, his appearance betrays a tension between the rigidity of a hard-nosed scientist and the spontaneity of an intuitive artist. His hair is ruffled and his slender body is draped in a long trench coat under which he wears a colorful Jackson Pollock-dotted aloha-shirt. As a trained physicist, mathematician and professor, he is an accomplished scientist. But he also sees himself as an artist with a visionary outlook. Thus, his own universe of ideas and beliefs, compliments his looks: to him, it is self-evident that, “artificial life is larger than biological life”, that life-organic or what biologists and artificial life researchers refer to as, “life-as-we-know-it”, is not the *only* kind of life existing in this world. Artificial life, he asserts, is “larger” than biological life because the universal concept of “life” transcends the natural order and it must therefore, he believes, be apprehended beyond the conventional logics of biology. “Life”, in other words, is in a highly volatile state, both materially, pragmatically and theoretically, and swathed in his larger-than-life-attitude, Ikegami believes that “life” may be better understood through artificiality, through the active material construction of new artificial systems. He is, in a word, on a mission to, “construct artificial life in the real world” by “enlarging” artificial life systems in terms of materiality, physicality, size, scale, and complexity, so that they become very “real” physical things in the “real world” in which we live.

This thesis is an anthropological tale about Ikegami and his team of researchers at the Ikegami Lab, exploring how they seek to “construct artificial life in the real world” and how Ikegami has managed to organize a new movement in science. Ikegami, then, is a central figure in this thesis, both in terms of how scientific change is brought about and in terms of how scientific practices are propelled through charismatic leadership. The lab members at the Ikegami Lab featured in this thesis have gathered around Ikegami and see him as a sort of prophetic figure, whose creed they follow, and whose mission they seek to accomplish. Together, their goal is once and for all to

better understand the highly elusive concept of “life itself” (cf. Foucault 1971) *through* constructing artificial life in the real world. Thus, this thesis is a story about how Ikegami and the lab members at the Ikegami Lab collectively struggle to get at the one overarching and fundamental question, “what is life?”, not simply by asking about it, but by synthetically constructing it from the “bottom-up”. But it is also a story about how a scientific community gathers around a charismatic leader, how technologies become objects of knowledge production and how paradigmatic changes in science intersect with, and transform through, individual personal qualities, emotional postures, affective relationships and charismatic leadership.

For Ikegami and his fellow artificial life researchers, who are featured in this thesis, then, “life” is not only an object to be epistemologically reworked and reconstructed. It is also an object that can be synthetically and materially constructed from the bottom up. What this means is that “life” is constructible category at the Ikegami Lab, both literally and metaphorically, something that can be built from scratch and something that can be built *into* technologies. In our present moment, Ikegami and his small group of researchers, officially naming themselves “artificial life researchers” - or “Alifers” - have clustered at the Ikegami Lab, to rethink and redefine, as they say, “what life is”, by, “constructing new life forms from the bottom-up”. Constructing new artificial systems, such as computer simulations and robots, they claim, is as a way to better understand what “life” is and what it might become, and so, *constructing* life, for them, means *understanding* life. Together, then, they seek to heighten the chances for getting at what life is exactly by constructing new artificial systems. However, the lab members have also clustered at the Ikegami Lab for another reason: because they have been enamored and captivated with Ikegami himself, his own cult of personality. To them, Ikegami is, they say, a “pioneer” and “genius”, who is leading a rebellion against what he terms, “normal science” – a mode of science bound by convention, tradition and custom, indeed, an enterprise, as they see it, which is detrimental to scientific and intellectual progress. As zealots of Ikegami, these artificial life researchers see themselves as being on the forefront of an insurrection against ways of doing science, against dominant paradigms, and so seek to reinvent, redefine and reconstruct how we understand “life” altogether.

What I offer in this thesis, then, is an ethnographic journey through the social and cultural tapestry of the Ikegami Lab. Here, “life” is nowadays being tweaked, amended, constructed, reconstructed and cobbled together, not simply from bits of biological materials, such as cells and genes, but from bits and pieces of silicone, rubber electronic circuitries, information, data, ones and zeroes, under the charismatic and visionary leadership of Ikegami himself. Operating out of one of the most prestigious universities in Japan – the University of Tokyo – these artificial life researchers have therefore gathered around Ikegami to invent so-called, “lifelike” technologies, they say, which are not practical tools for everyday convenience, but rather tools with which to theorize “life itself” (cf. Foucault 1971).

While their artificial systems are tools with which to theorize life, they are not exclusively scientific objects. As somewhat bizarre and unusual inventions, they also feature at art exhibitions and symposia around the world. “Lifelike” machines, such as the Taylor-Couette-Flow, circulate the principles of fluid mechanics that realizes the principles of the Taylor-Couette-Flow thereby “autonomously” generating enthralling sound patterns based on chaos mapping. In museums and concert halls, one may encounter human-shaped androids that perform operas and conduct symphonies with human orchestras. And in underground music clubs in Tokyo, one may join concerts with graphical bit-patterns jumping on large screens synchronized to the tunes of glitch, industrial electronic music. What these things share is that they somehow allude to viewers that they are somehow “alive”, or “as if” alive, while overtly appearing to be wholly synthetic. They are, in other words, vivid, auditory and visual technologies that are seemingly imbued with “life” or some living quality. But they are also recent materializations of a sort of artificial life. They are, in a word, the material results of the sort of work Ikegami and his team of researchers do at the Ikegami Lab, and as such, they are scientifically inspired artworks meant to be nascent “lifelike” technologies that are made of synthetic materials, which may trick us into reflecting on the relationship between life and nonlife, and the potential possibility for achieving “life” by technical means.

In the final years of twentieth-century, those who would eventually come to call themselves artificial life researchers emigrated from computer science, mathematics,

physics, programming, biology, neuroscience, biochemistry, psychology, electrical and mechanical engineering (cf. Langton 1989). Collectively, they resolved that if the aim of artificial life was to *understand* life, then *constructing* it would yield better theories than would conventional experimentation. The lab members at the Ikegami Lab advocate not simply experimentation but construction, not simply analysis but synthesis, not simplicity but complexity, in their quest to explore, as they say, “what life is and how it works”. Gathering around Ikegami and arming themselves with a range of advanced technologies (computers, robotics, etc.), experimental tactics, and programming techniques, they are in the business of reassembling both the object and the project of artificial life, that is, to rework artificial life materially, theoretically, and socially. As an anthropologist of science and technology, I have spent about 7 months talking to and working with them.

According to Ikegami – who is himself a trained physicist and complex systems scientist from the University of Tokyo, graduating from the Department of Physics in 1984, finally becoming a Doctor of Science in physics in 1989 - the lab has since its establishment progressed through different “eras” leading up to the present moment. During the 1990s, around the time the Ikegami Lab was established, Ikegami himself garnered interest in realizing his long-standing dream of artificial life: to construct, in his words, “artificial life in the real world” upon his self-crafted aphorism and assumption that “artificial life is larger than biological life”. Artificial life, Ikegami claims, is “larger” than biological life because contemporary biological definitions of life are too limited and too narrow in truly capturing the volatility and grandiose nature of life itself. In pursuit of his dream, Ikegami officially began his studies in artificial life during the early years of the 1990s, which are now formulated on the lab’s website,

In this laboratory, we have been working in the field of artificial life for more than 15 years. Evolution of genetic codes, mutation rates and cooperative relationships were the target of the first era of this lab. Then complexity of coupled cognitive systems were studied using dynamical recognizers and other recurrent neural (often embodied) systems. This was the second era. Recently, we have entered the third era which is to

construct artificial life in the real world. Any basic science can lead to innovation applications and Artificial life studies is no exception. In order to fruition the concepts developed through the study of artificial life, such as ‘autonomy’, ‘enaction’, ‘sustainability’, and ‘evolvability’, we have newly started several experimental and conceptual works, using chemical experiments, the internet, web, and some artworks.

When I arrived at the Ikegami Lab, as an anthropologist with the ambition to undertake ethnographic fieldwork, first in spring 2017 and later in spring 2018, the lab members had been pursuing their self-described mission to construct artificial life in the “real world” for at least two years. Although the lab members on an everyday basis engage in many individual research projects related to the study of (artificial) life – ranging from doing research on topics such as “cognition”, “memory”, “genetic codes”, “mutation rates”, “swarm intelligence”, “collective intelligence”, “perception”, and “agent-based models”, that is, topics they associate with “life” and the “living” – their agendas are altogether different in scope and aim, having multiple aims, goals and objectives. However, what they all have in common besides their official titles as artificial life researchers and their constructive approach to life, I found, is a collective fascination and reverence for Ikegami himself, his wit, intelligence and charisma.

Thus, what they share is not only belief that “life” is something that can be understood through its technical and material construction, but also their social commitment to Ikegami, who is arguably the spiritual leader of the lab. That is, what they also share is admiration for Ikegami’s visionary and creative prowess and his way to offer philosophical, metaphysical, ontological and epistemological guidance. Joining Ikegami and the lab members, this thesis embarks on a journey to 1) pick up on how “life” is nowadays being understood not simply by studying it at a distance, or simply by theorizing it, but by constructing it from bits and pieces of synthetic materials and in silico, and 2) to explore how charisma and paradigms intersect, that is, how charismatically-certified modes of authority in science may propel scientific practice and bring about paradigmatic change.

What I seek to address, then, and hopefully to capture in some compelling way, is how efforts at the Ikegami Lab to better understand what “life” is by constructing it is motivated not by a range of technical and historical possibilities but also largely by Ikegami’s charismatic leadership. By being a sort of prophetic leader in science, Ikegami is almost single-handedly the one, who organizes both philosophical, metaphysical, ontological and epistemological orientation of the lab. In other words, he has created his own cult of personality, with his own followers together with whom he seeks to articulate and establish his own paradigm. As such, I hope to show how some of the most powerful social forces driving these artificial life researchers reside in the charismatically-certified set of norms articulated by Ikegami himself, as a visionary and prophetic leader, whose charisma and leadership propel scientific practice and potentially bring about a paradigm shift. In other words, “what life is”, and how these people operate to give assertive or speculative answers to their own questions, are simultaneously shaped and reshaped by social commitments and how technologies shape and reshape ideas about what life may be said to be in our contemporary moment. However, still, such social commitments revolve around Ikegami himself, a larger-than-life character who commands his zealots in a struggle to assert and prove once and for all that artificial life is “larger” than biological life. Joining the Ikegami Lab as an anthropologist, I therefore seek to pick out instances of how the lab members collectively work to bring to “fruition”, as they say, to those concepts they associate with life and the living, but also how they seek to bring fruition to Ikegami’s creed. Artificial life, at the Ikegami Lab, I hope to show, is a social formation marked by a certain mode of leadership and followership, where Ikegami’s flamboyant personality is pivotal to the creation of a scientific community of followers, who work to construct new, as they say, “experimental and conceptual works, using chemical experiments, the internet, web, and some artworks”.

My central argument in this thesis is that scientific practices, knowledge production and paradigmatic change, may equally be propelled by a specific mode of charismatic leadership and authority, which is here embodied by Ikegami. As such, I claim that scientific practices and paradigmatic change may equally be rooted in a sort of “charismatic authority” (cf. Weber 1954) - a form of authority, governance and power, which is exclusively derived from Ikegami’s personal qualities of being a

charismatic, charming and seemingly trustworthy leader. More precisely, this means that Ikegami is a central actor in shaping affective relationships between lab members and in motivating belief that artificial life is “larger” than biological life. Indeed, as I will show, the social structure of the Ikegami Lab organized as an emotional collectivization, which is held together by an affective and emotional bond between lab members and Ikegami. Ikegami offers to lab members philosophical, metaphysical, ontological and epistemological guidance, what may be termed a universal, “ontoepistemological” framework (cf. Barad 2007), as a device through which to see and attend to the world and that offers for lab members both an ontology of the world and an epistemology with which to apprehend this world. And so, I want to take this claim a bit further and show how Ikegami’s self-made and charismatically-certified ontoepistemological framework that I call *Ikegamianism*, coalesce on the construction of what I call *parallax machines*, which in turn also reflect what I call a *parallax view of life*.

The concept of parallax machines, then, refers both to the material construction of new, embodied artificial life systems, the materialization of Ikegamianism *and* the social construction of a parallax view of life. Thus, while Ikegami and his style of leadership are main components of this thesis in terms of how scientific practice and change happen, one of my central claims is also that parallax machines do a lot of work for Ikegami and his team of researchers: they are epistemic things that serve to destabilize biologically-established understandings of life (cf. Rheinberger 1997); machinic objects that materialize social worlds; things with which to build new viable instantiations of human-machine interfaces in the sense of creating new modes of human-machine relatedness, relations that can be made only by constructing new artificial systems in the real world; and social tools for building alternative narratives of life, narratives that offer what I call a parallax view of life.

I will unpack these concepts later on in this introduction, but to go quickly, Ikegamianism is shorthand for the ontoepistemological framework by which the lab members operate, which include a set of beliefs, principles, norms and values to which the lab members adhere. A parallax view of life, in the simplest of terms, is a culturally specific perspective fostered by the lab members at the Ikegami Lab, which

allows them to refrain from relegating their primary scientific object of inquiry, “life”, to be a “natural kind” (cf. Strathern 1992). A parallax view of life, in other words, is a culturally specific vision of vitality that expands the category of “life” to include both the “natural” and the “artificial”, rendering what counts as “life” to a matter of both-and, that is, and perhaps paradoxically, a matter of being *simultaneously artificial and biological*. Thus, parallax machines both materialize Ikegamianism and offer a parallax view of life.

The notion of a “parallax” - parallax machines and parallax views - is inspired by the many modes of parallax found elsewhere in modern theory, for example such as the wave-particle duality found in quantum mechanics. But the concept of parallax machines, to be clear, is of my own invention, an analytic term I develop on the basis of my fieldwork to unpack how the artificial life researchers at the Ikegami Lab are not only constructing new artificial technologies (i.e. androids, computer programs, etc.), but also, while doing so, both materializing and constructing their own views of the world. Artificial life at the Ikegami Lab, through the work of constructing parallax machines, then, is a social and cultural enterprise that perpetuates in ontoepistemological vertigo, in which the material construction of parallax machines gets tangled up in the interstices of realms social and cultural, organic and inorganic, natural and artificial, living and nonliving, real and simulated. In a word, what will hopefully become apparent throughout this thesis is that parallax machines, Ikegamianism and a parallax view of life are inextricably interrelated.

Now, in order to arrive at this conclusion, I will take the reader through the social and cultural circuitries of the Ikegami Lab to show how the lab members have arrived at the conviction that artificial life needs to be constructed in the real world in the first place. Thus, to go back to the idea that the field of artificial life, and the Ikegami Lab itself, has progressed through a set of different “evolutionary” stages, or “eras” (from the “computer era” to the yet-to-be-named “third era”), this thesis is first and foremost an anthropological story about how scientists, i.e. lab workers such as the artificial life researchers featured in this thesis, become “followers” or “disciples” of movement centered on one charismatic figure, how they describe and understand “life” and things they make, and how scientific paradigms are simultaneously

deconstructed, broken down, reconstructed and reestablished through the work of leadership, namely through a very special sort of charismatic leadership.

The research conducted by the lab members at the Ikegami Lab is therefore not for serving any discrete pharmaceutical, commercial or agricultural functions. Rather, as these researchers have gathered around Ikegami, they have come to insist that their commitment to construct new artificial systems in the real world exclusively serves a sort of discovery science. Constructing new material things, such as androids, are not, for example, about satisfying some commercial need or about improving upon, say, healthcare, medical or agricultural systems. Rather, constructing “artificial life in the real world”, or better, as I claim in this thesis, the construction of parallax machines, is about *building social dynamics and scientific arguments into machines*. Again, parallax machines, in turn, become material and abstract entities that persuade or convince audiences, scientists and publics alike, that artificial life is a viable possibility, indeed a technical reality, and that artificial life’s vision of the world is indeed a credible one. The construction of parallax machines, then, is a way to harness, store, and produce a culturally specific world(view), by which I mean that parallax machines simultaneously materialize the social dynamics of the Ikegami Lab and produce a parallax view of life. Yet, the production of such a world(view), I hope to show, is a social practice mobilized through a range of diverse social interactions, most prominently the work of charismatic leadership.

Finally, this self-evidently begs a multitude of anthropological questions, which may occasionally overlap with those of my interlocutors: What is life? What is natural? What is artificial? What is the biological? What is the real world? What is artificial life? What does it mean to “construct” (artificial) life? What does it mean to “understand” (artificial) life? How did wanting to construct (artificial) “life” in order to understand it become paired questions pushed into a relation of equivalence? How is the Ikegami Lab organized? How do they understand “life”? How do they really construct new systems, and so on? These are questions that may already appear to apply pressure to what life *is*, or what it could be said to *be* in our present moment. But they may also appear to reveal that questions about what life is, and what it may someday become, are tethered to a range of social, cultural, material, technological,

discursive, conceptual, ontological and epistemological commitments, first and foremost *human* commitments to somehow give *form* to life, both materially, conceptually, rhetorically, discursively, ontologically and epistemologically.

If artificial life, in its most canonical and highly capacious expression, as the field's founder Christopher Langton (1989) notes, is about abstracting "life's logical form in different material forms" (cf. Langton 1989), the notion of *constructing* artificial life in the *real world*, I think, raises fresh questions about which kinds of materiality may harbor life's logical form, and by what social processes, norms, logics or narrative conventions such forms may be captured, harnessed, apprehended, reshaped and ultimately made sense of. Why, for example, is one required to construct artificial life in the real world in order to understand what life is and how it works? What is the real world? Finally, what new meanings or definitions of life may the construction of what I call parallax machines potentially bring about? What I will show is that lab members at the Ikegami Lab are human beings and social actors, who gather around Ikegami, to vividly bring about what I call a parallax view of life - a view both ontologically and epistemologically extending "life" into a more capacious and plastic domain beyond the logics and modes of biological reasoning - into the conjectural, into thinking about life's future forms.

Artificial Life in the Real World

The field of artificial life has been variously described as a heterogeneous technoscientific formation, based, to a large extent, on an interdisciplinary ethos (Langton 1989; Whitelaw 2004). Yet, despite the field's heterogeneous formation in terms of disparate epistemological orientations, interests and research programs, some scholars have pinpointed the field as a "culture of simulation" (Turtle 2005; Aicardi 2010) – a culture, or a community of people, held together by a collective aim at understanding the characteristics of life by simulating them in *silico*, particularly by people familiar with, and possessing skilled mastery of, informatics (cf. Turtle 2005; Helmreich 1998; Aicardi 2010). That is, insofar artificial is a "science of simulation", it is a field premised on a perpetual reevaluation of its founding category, "life", and

of the experimental and theoretical implications of its methodology, computer simulation (Helmreich 2001:613).

When the field of artificial life was officially drawn into coherence by the field's founder, Christopher Langton, by the end of the 1980s, practitioners have basically been relying on computers for abstracting the logical form of life (cf. Langton 1989), which meant for them that "life" could be considered a formal, coherent and unifying quality that could exist and take hold in *any* material substrate, such as machines, computational media, or even elsewhere in the universe (Helmreich 2016). While the lab members at the Ikegami Lab carry much of this tradition, they are not, however, fully convinced that "life" may take hold in *any* material substrate, especially not in computational media. But this is not to say that working with computational media is irrelevant for lab members at the Ikegami Lab. Many of the them, I experienced during fieldwork, have over years of training in computer science or engineering, acquired an impressive skillset that allows them to program in just about any programming language. Thus, to this end, many of them still engage in attempting to understand some essential characteristics, features or properties of life by seeking to simulate them in self-made computer models, for example, such as "evolution" or "mutation rates", categories many of the lab members associate with life.

However, in reaching the so-called "third era" – the contemporary era, in which we now find ourselves - the common view among the lab members is that computer simulations cannot adequately capture, nor harness or pin down the essential characteristics and properties of life. Nor may computer models be marshalled as convincing evidence of "real" life; they are, many of the lab members say, simply "simulations" not to be mistaken for "real life". Computer models, however, may still effectively, and sometimes evocatively, display somewhat accurate representations of some feature of life or some specific features of living activity, for example such as "evolutionary processes", "mutation rates", or other forms of reproduction. But one of the main problems of computer simulations, however, is still that they are not "powerful" and "complex enough", as some of the lab members say, to truly "become life". In other words, running a simulation of some evolutionary process, for example, is not adequately "complex" enough to fully convince the lab members at the Ikegami

Lab, and their academic adversaries, that this is indeed “real” evolution. This is, among other things, partly because computers operate according to binary logics, but it is also partly, as Ikegami tells me, because “complexity is something that is higher in the real world compared to a computer world.” Computers, then, according to Ikegami, may be good at simulating causality, for example, be good at unfolding, in a linear fashion, a series of causal events, which in turn allow digital “organisms” to “evolve” in chronological lockstep. But the real world, on the contrary, cannot, as Ikegami sees it, easily be reproduced and simulated in computational media, nor simply be reduced to mechanistic functions. Or, in the words of Ikegami, “computers can generate very high levels of complexity, but it is a level of complexity, which is different from what you see in the real world.” The complexity of the computer, as it were, is only a sort of “controlled complexity”, a sort of complexity too tightly held within braces, too constrained, too rule-governed.

Such a belief, needless to say, problematizes Langton’s field-founding assumption that life’s logical form – an idea premised on the assumption that life is a formal effect - can be abstracted in computational media. But it does not problematize the idea that life may take hold in any material substance, computational or otherwise. This commitment to the “real world”, nonetheless, reveals that the lab members at the Ikegami Lab have lost faith in the ability of computers to capture what they anticipate or believe to be baseline principles of life: “life” is not something captured within a computer, “in there”, as some members say, something to be simulated in the tightly controlled domain of software. Rather, “life” is something happening “out here”, in the real world, a highly stochastic, erratic, uncontrollable and unpredictable world. And so, Ikegami asserts, “life is lived, not simulated,” and it is the “real world”, the lab members should be committed. To this end, computer simulations amount to nothing more than simulations, and therefore, according to Ikegami, inadequate for theorizing the what Langton called the “biology of the possible” (Langton 1989) – that is, for theorizing “life-as-it-could-be”, simply because the level of complexity they are able to produce do not correspond to the complexity of the real world. What is at stake among the lab members at the Ikegami Lab, then, is an ambitious effort to overcome the limitations of computational media in order to produce, indeed to construct, very real instantiations of life outside the confines of virtual worlds. Thus,

if early efforts to simulate some property or process of life relied only on the use of computer simulation, the meaning of constructing artificial life in the real world, according to Ikegami, is tethered to an aspiration to transcend and overcome the limitations of the digital.

Following along the Ikegami Lab's efforts to overcome the limitations of the digital to truly become "life", constructing artificial life in the real world, as I will show in the course of this thesis, is the goal. But the means to get there, however, as I will argue, is largely motivated by Ikegami's style of leadership, his universe of ideas and layouts of reality, and as such, their work is motivated by and tethered to a very specific, culturally contingent world(view), a view that holds that the real substance of "reality" - what Ikegami calls "massive data flows" - "is overflowing with excess data flows and information". More precisely, what counts as the "artificial" and the "natural", the "real" and the "simulated", and the boundaries between them, is a product of dynamic interactions: life is "lived", as Ikegami notes, it is "real", happening "out here", in everyday life in a volatile world, whose stochastic dynamics cannot be computationally modelled, replicated, or "simulated". How exactly this culturally specific world(view) is produced is a central concern in this thesis, it is indeed, I will claim, the work of performing an ontology (cf. Blaser 2009). And Ikegami, I will show, is central to the articulation of this ontology.

Thus, one practical solution to overcome the digital is the construction of "larger" artificial systems in terms of materiality, physicality, size, scale, and complexity, systems, whose dynamics and possibilities of interaction correspond to what Ikegami also refer to as "real world dynamics" – i.e. to the forces at work "out here". The only way to heighten our chances to better understand life, then, is constructing new physical, embodied machines, such as robots, for example, composed of electronic circuitry, or new chemical systems, composed of oil, acid and/or lipids, are ways to "enlarge" artificial life systems, so that they gain tactile physicality, which corresponds to the complexity of the real world. This, the lab members claim following Ikegami, may in turn advance their understanding of what life is, what it may become, and how it works on a more fundamental and profound level than regular discovery-based experimental science can uncover.

Now, while robots, for example, feature among the things they are constructing at the lab, for example the android Alter featured in this thesis, Ikegami clarifies to me that they are not roboticists and that artificial life is not synonymous with robotics. Rather, Ikegami is annoyed by widespread misunderstandings in mass media and even within academic circles mistaking artificial life for robotics. And so, Ikegami openly opposes a recent tendency to view Japan as a “Robot Kingdom” (Schodt 1988) – a notion of Japan as a place more philosophically and culturally attuned to technological development. This view has been generously expanded and discerned by many social scientists before, and indeed, many social scientists have been captivated with questions about the interrelations between, “Japanese robotics”, “technology”, “animism” and “culture”. Ikegami makes it clear to me, seemingly very aware of this complex being an object of concern for social scientists in particular, that this is not how artificial life works.

In much of the social scientific literature on robotics in Japan, it has variously been described as a place where people are, “loving the machine”, a place where robots are, “priceless friends” (Hornyak 2006). Moreover, many scholars have been preoccupied with those specific “cultural” factors, often such as Shinto and animistic belief, as central components in how the Japanese, often in contrast to the “West”, craft favorable representations and positive images of robots (see Geraci 2010; Kaplan 2011; Kitano 2006). Others have sought to extend this argument by examining in more detail the so-called “co-construction” of “robotics” and “culture” in Japan (Sabanovic 2014) or how “sociable robots”, developed in Japan, practically become “warm, caring, affective, confessional and social” to people, i.e. human users (Leeson 2017). Such accounts predominantly highlight the linkage between seemingly unique “Japanese” cultural resources, as foundational for the making and perception of technologies inside and outside Japan, especially the perception of humanoid robots. While there are links between how robots, or rather how artificial systems, become affective, Ikegami insists that artificial life is a field in its own right not to be mistaken for robotics. But this, in turn, does not mean that artificial life is not in some way aligned to robotics. Indeed, as we shall see, the artificial systems they make at the Ikegami Lab, such as the android Alter, embody and elicit many of the same aspirations fostered by roboticists.

Computer simulations, then, in relation to, say, robots, are, according to Ikegami, badly equipped to truly replicate the volatile dynamics of the real world, a world that is both ontologically, experientially, and qualitatively different from the dynamics replicable in digital simulations. On the contrary, robots offer a physical presence and a tactility more in tune with the dynamics of the real world; robots, in short, offer that we connect and respond to them in affectively through sensory experience. In turn, if this is the case, it requires of Ikegami and his team of researchers to design, develop, and construct new artificial systems *in* the real world.

Once this has been achieved, Ikegami continues, what is needed is what he calls a “new epistemology of artificial life”, an epistemological outlook that is better equipped to deal with a complex world. Once again, as Ikegami notes, if “the level of complexity in the real world is more complex than the level of complexity one finds in a computer”, the “real world”, Ikegami further claims, “provides sufficient complexity and large data flows to conduct an effective analysis.” In other words, the real world can itself be interpreted as a large-scale experimental site by which to conduct an effective analysis of what life is, and therefore, one needs to learn *how*. Hence, their commitment to what they colloquially term the real world, or “real world dynamics”, or “massive data flows”, in short, the ontology of the world, is simultaneously, I will claim, an epistemological commitment not to mistake the complexity of computer simulations (and their visually appealing resemblances to “real” life) with the ontological complexity of the real world. Put differently, in their words, constructing “larger” artificial systems, in terms of materiality, physicality, size, scale, and complexity, is the only way not to “reduce complexity”, and instead to harness and understand “complexity as it is”, upon the realization that the world is, ontologically speaking, “messy”. Following from this ontological claim, Ikegami sees that a “new epistemology” is needed, one by which to better sound out, he says, “new meanings of life”.

Their commitment to what they describe *as* the real world, as a domain seemingly separate from the digital world, I thus want to show in this thesis, is a social and epistemological commitment, whose conditions of possibility is tethered to the active making of a *culturally specific ontology*, one that picks out the real world as a complex jumble of massive data flows, only to be harnessed by 1) constructing artificial

life in the real world and 2) by developing a new epistemology of artificial life. The “real world”, in which these researchers seek to make new things and new knowledge - namely the world in which they seek to make new artificial systems and meanings of life - I will therefore argue, is indeed *one that is also constructed, both in practice and in discourse, both ontologically and epistemologically at the Ikegami Lab*. The lab members, I claim, do not only construct new technologies, but they also construct worlds. Constructing new, embodied artificial things in the real world, then, is animated by a collective devotion to detach and decouple, both their faith in computational media and the systems they make, from the (limited) virtual realm of computer simulation in order to reinsert artificial life into the real.

Context: Calibrating Life’s Form and Matter

If artificial life is amenable for material construction in the real world - indeed a thing subject to the same engineering strategies and programming techniques employed for making the nonliving world - then it may automatically entail that “life itself” (cf. Foucault 1971) may be apprehended not only in some future perfect tense, but also in some constructive sense. This much is clear at the Ikegami Lab. Yet, endeavors to understand life’s *form* by its *matter*, and vice versa, or more precisely, by constructing “life forms”, as those embodied bits of vitality we usually know as “organisms” (cf. Helmreich 2009) in order to infer from them how life works on a more profound level, have not always been constructive or even projective. To this end, the lab members at the Ikegami Lab may be part of a much more recent trend in academic research in the life sciences that treat “life” as a constructive category.

In their investigation of the term “life form”, in their article *Life Forms: A Keywords Entry*, for example, anthropologists Stefan Helmreich and Sophia Roosth (2010) write, “‘life form’ has, since its earliest nineteenth century enunciations, pointed to a space of possibility within which life might take shape. Exactly how that space is understood and theorized has transformed as the term has traveled into the present. We suggest that ‘life form’ has moved from its origins as a term referring to abstract, idealized, aesthetic possibilities through reference to biogeographic and evolutionary

possibilities to, today, conjectural and future possibilities.” (Helmreich & Roosth 2010:27). Here, as Helmreich and Roosth suggest, the *form* of life has had many enunciations through time, which posits that the notion of form may be a sort of empty signifier, which can then be furnished with different meanings or possibilities. If one looks at biological modes of thinking about life forms, and life’s relation to form, for example, as Helmreich and Roosth further show, such thinking has been churning life’s form in modes inductive, deductive, and abductive (Helmreich & Roosth 2010). But the point I want to make from this in relation to the Ikegami Lab is to discern *how* exactly this space is understood and theorized, that is, how lab members themselves seek to imbue *life* with a specific kind of *form*.

Artificial life at the Ikegami Lab is no exception to this history of wriggling life to form. However, what they are trying to do at the lab is exactly to understand and theorize life’s *form* by *constructing* new artificial artifacts, which in turn enable them to grapple with how to determine or resolve the relation of form to life. And in doing so, the lab members at the Ikegami Lab join a cacophony of scientific obsessions with life, which has long been tethered to broader interests in extracting and inferring its *form from its matter*. To this end, the objects and phenomena to which the notion of the life form refers are always-already, as Helmreich notes elsewhere, framed by conceptual commitments (Helmreich 2016), which adds yet another important point to the work of the Ikegami Lab: what counts as “life” is shaped and reshaped by conceptual commitments. But, in the context of the Ikegami Lab, I would also like to add that such conceptual commitments are here further complimented by material and technological commitments in an era when life’s substance is something rendered amenable for technical, algorithmic and material (re)construction, commitments, I will claim, that offer new conceptual possibilities for understanding it: the very practical construction of new artificial systems, I think, allows for furnishing *life* with new *forms*, not just material forms, but also social forms, meanings, possibilities, even ontological and epistemological claims and assertions about the world.

Now, if, as philosopher Michel Foucault (1971) once claimed, “life itself” is a category that “did not exist,” before it manifested in the early nineteenth-century, as the organizing object of concern particularly for biology (Foucault 1971), the invention of the category of life itself warranted that the living world demanded a

science of its own. In other words, as the discipline of biology – the natural science that broadly studies life and living organisms, including their physical structure, chemical processes, molecular interactions, physiochemical mechanisms, development and evolution - itself manifested around the 1800s, it posited “life itself” as its animating object exactly upon recognizing the living world (bios) as ontologically distinct from the nonliving world (geos) (cf. Povinelli 2016). The invention of the notion of “life itself”, according to Foucault, thereby bifurcated and carved up the world into the living and the nonliving world. But if biology has always been, since its inception, and still is by definition, an inquiry into the living world, the question of life – namely the question, “what is life?” – has over the past century or so admitted various answers (Helmreich 2016; Praet 2015).

In the mid- to late nineteenth-century, Charles Darwin’s theory of evolution, for example, offered an account of how living form materialized out of what is now commonly known as environmental or ecological dynamics (evolution). For Darwin, the “forms” at stake in his theory of evolution materialized in “species” or “organisms”, as durable but changeable genealogical kinds. “Species” and “organisms”, Darwin believed, were different, not in variation, but in kind. However, if Darwin located his theory of evolution in natural history and biology, the twentieth-century hatched a variety of theoretical efforts that expanded upon Darwin’s biological theory, efforts that sought to amplify explanations of living form, especially by locating such accounts in the more universal territories of physics, chemistry, and mathematics. For example, before the discovery of the double helix structure of the DNA molecule, the physicist Erwin Schrödinger (1944), in his book *What is Life?* offered an account that life might issue from a hereditary “code-script”, a form that was in subsequent years enlisted into models of DNA and into informatic and cybernetic visions of vitality (Helmreich 2016). Many years later, however, the microbiologist Lynn Margulis and writer Dorion Sagan (1995), on the contrary, provided a less unitary account in their book, also titled *What is Life?* in which they offered a distinct answer to the question for each of life’s five kingdoms: bacteria, protists, animals, fungi, and plants. Not exactly in line with Schrödinger’s idea that life could be recognized as a code-script - indeed that life’s form was essentially *code* (cf. Kay 2000) - Margulis and Sagan emphasized that neither some underlying logic, nor some overarching metaphysics, were key to explain life’s form. Rather, they

argued that the situated specificities of microbial, fungal, plant, and animal embodiment were key to understand life, not as compressed into the linear logic of code, but as a process ever overcoming itself in an assortment of embodied manifestations (Margulis & Sagan 1995).

Now, needless to say, there is a polyglot of other epistemic lineages and scientific accounts that track answers to the question of life. But what most biological accounts of life exude is mainly the attempt to somehow distill life's essential form from its matter, where some accounts, like the one offered by Schrödinger, leveraged universal explanations of life, while others, like the one offered by Margulis and Sagan, leveraged more particular explanations of life. But such forays, whether locating their accounts in the universal domain of physics, chemistry, mathematics or not, generally fell under what came to be named "theoretical biology". Theoretical biology, in turn, came to thrive in parallel to more conventional approaches in biology, a field that is itself understood to have begun with the work of D'arcy Wentworth Thompson (1917). Thompson, for example, in *On Growth and Form*, from 1917, argued that the shape of organisms was both constrained and shaped by physics, by a sort of mathematics or geometry of nature. Foreshadowing Schrödinger, Thompson drew on the language of physics to make sense of life, believing that embryology could learn much from studying crystal growth patterns (Thompson 1917). Yet, the field of theoretical biology never fully reformatted or reconfigured the dominant empirical and experimental traditions of biology itself and never really broke the dominant paradigm of biology. However, theoretical biologists did nevertheless bring into relief how the "form" in "life forms" came to be epistemologically extended into domains beyond conventional biological modes of reasoning, even into the conjectural, to think about life's future forms (Helmreich 2016:30).

It was not until the 1930s, though, that a dominant – and perhaps even axiomatic – biological understanding of life really began to manifest, as molecular biologists increasingly came under the sway of the so-called "protein paradigm" - a paradigm holding that proteins fundamentally governed heredity and that the fundamental building blocks of life was organic molecules: proteins and nucleic acids, lipids and carbohydrates (cf. Roosth 2017). Throughout the years of the Cold War, the protein

paradigm increasingly came to eclipse Schrödinger's idea to understand the "physics of life", which had nevertheless made a heavy contribution to how molecular biologists began to pose the question of life as a "coding problem" (Keller 2002). The protein paradigm became so powerful that in 1954, for example, the biochemist Jacques Monod (1961) went as far as to say that, "anything found to be true of *E.coli* must also be true of elephants" (Monod & Jacob 1961:393), a notion that held molecules to be the unitary quality common to *all* living organisms. Despite the later invention of recombinant DNA technology in 1973, which then allowed scientists to "engineer" bits of DNA between and across different species and organic compounds, allowing in turn for an unprecedented control over molecular biology, the emergence of DNA technology was still held under the sway of the protein paradigm. And in subsequent years, the protein paradigm held most biological research under its spell, at least up until the discovery of the double helix structure of the DNA molecule (Roosth 2017; Praet 2015).

The Emergence of the New Sciences of the Artificial

During the 1980s and 1990s, and by the late 2000s, biological obsessions with genetic sequencing proliferated and culminated in the "Big Science paradigm" - a paradigm still widespread to this day. Perhaps one of the most famous of such obsessions with genetic sequencing might be the Human Genome Project (HGP) – a large-scale international research effort to determine the sequence of nucleotide base pairs that make up human DNA. Thus, by century's end – concomitantly with the establishment of the Ikegami Lab at the University of Tokyo - biology and many other technoscientific enterprises, including artificial life and later synthetic biology, had once again begun to wager on what might constitute life's essential form, function and even meaning. Such endeavors, once again, began to locate accounts of life not only in the universal territories of regent disciplines, such as physics, chemistry, and mathematics, but also in the domains of information science, computer science and informatics (cf. Keller 2002; Kay 2000; Helmreich 2016). Life, in other words, had become target for digital simulation and bioinformatic representation (Helmreich

2016:1).

By this time, the relations between life's form, materiality, function and meaning came not only to be known and determined analytically according to the logic of computation and informatics, but also *synthetically* or *constructively* by technically linking the fundamental mechanisms that joined living structure to living function, matter to form (Johnston 2008; Helmreich & Roosth 2010; Helmreich 2016; Roosth 2017). But while life and its mechanisms became amenable for, and known through, synthesis and informatic idioms, and not just analysis, the locus for mid-century and millennial biologists was still primarily molecular: proteins, nucleic acids, lipids and carbohydrates, to be sure, were still essentially held accountable for all living processes, the matter by which to identify life's essential form. Yet, an off-shoot of alternatives, such as artificial life, began to spring from this and began defining itself against the protein paradigm, centering attention not on DNA, as the basic building block of life, but on *information* as a primary quality shared by all living things¹.

Newfangled interested in the questions of life, from the inception of biology pacing up to our present moment, may now have reached its redux as it comes apparent in the scientific journal, *Nature*, for example, posting an article in 2007 titled *Meanings of Life*, spotlighting the promise of synthetic biology to manufacture new artificial organisms from molecular parts (Nature 2007). Such new promises have taken life to be understood through its manufacture, a trend also captured in what science scholar John Johnston (2008) has called the “new sciences of the artificial” – a new set of sciences, such as synthetic biology and artificial life, which promises to deliver fresh definitions of life. Scientists, working in what Johnston labels the new sciences of the artificial, have thus proceeded to grapple with the question of life between two semantic zones of overlapping complexity: the metaphysics of life and the history of technical objects (Johnston 2008:3), subsequently bringing with them a slew of advanced technologies to synthesize and sequence life and vital processes. To this

¹ The field of cybernetics, emerging in the 1950s, for example, not only became a strong inspiration to the information sciences of the 1980s and 1990s, but also for artificial life itself. Cyberneticists during this period began seeing, for example, humans as “systems of communications”, as an adaptive cybernetic system of circuits that receive, process and transmit messages with surrounding systems (cf. Pickering 2010). Such a view also gave way for thinking about humans, animals and machines as complex adaptive systems that may best be defined by their relationships they create between inputs and outputs. In short, what came to circulate between human, animals, and machines, as few among many systems, was not just energy or particles, but information (Kay 2000; Pickering 2010).

end, marshaling and using new types of computational tools and information technologies have aided both artificial life researchers and synthetic biologists in gradually unwinding the so-called “facts of life”, now crumbling under new research paradigms. However, while synthetic biologists nowadays operate to reassemble new biological things from bits and pieces of existing biological things, artificial life researchers have turned to query life outside its biological moorings, namely in the virtual worlds of computer simulation and in the hardware realm of robotics, i.e. in the realm of artificiality, data and information.

Yet, while the protein paradigm to this day still remains intact, live and well, life is increasingly being thrown off course, entering a fresh identity crisis when new technoscientific formations, such as artificial life and synthetic biology, are rising. Such an identity crisis surfaces, I think, in part by the fact that practitioners in the sciences of the artificial are beginning to see life as a rather obstinate and persistent enigma that keeps evading their attempts to truly understand it. Life, in other words, is today once again a thing in transformation, if not outright dissolution, as contemporary uncertainties about what life *is*, for example, is evidently engendered not only in artificial life and synthetic biology, but also in the field of astrobiology. The field of astrobiology adds yet another branch of research, which is however separate from, but still overlapping with, artificial life and synthetic biology (cf. Thacker 2010; Praet 2015). But unlike artificial life researchers or synthetic biologists, astrobiologists, formerly known as “exobiologists”, look to outer space for extraterrestrial life, using advanced acoustic devices to bring “extraterrestrial life” within earshot, thereby into human knowability. In the process, they ask themselves questions like, “Is there life beyond Earth? What is the future of life in Earth in the universe?” (Thacker 2009:31), pondering what life might look like, or rather sound like, in such extraterrestrial worlds has today become an enigma.

But what such curiosities, generally shared by scientists in the new sciences of the artificial (and the extraterrestrial), also reveal, I think, are widespread scientific concerns about what constitutes life’s form and matter. But such concerns, I ponder, may be equally haunted by anxieties about what form *theory* might take when probing life’s limit cases in extreme environments such as outer space (astrobiologists) or deep sea (marine biology and oceanography), or fringes of “nature” or the biological

(artificial life and synthetic biology) (cf. Helmreich 2016). These days, although in very different ways, astrobiologists, marine biologists, synthetic biologists and artificial life researches search for new signs, traces, meanings and definitions of life that have them stir up new conceptual troubles, asking about the basic building blocks of life. But while astrobiologists use acoustic devices to bring “extraterrestrial life” within earshot, and while synthetic biologists manipulate the biological “stuff” of life, both doing so in seeking fresh answers to old questions about what life is, artificial life researchers - those who feature in this thesis - are more inclined to query what might be termed a sort of “supra-biological life”, a sort of life located at the fringes of biology. That is, a sort of life only knowable through its artificial construction, not in the void of the cosmos, or necessarily in the wetness of a petri dish (although they do), but exactly by reassembling bits of silicone, rubber, and aluminum with ones and zeroes, bits and bytes, energy, data, and information.

Hence, the context of artificial life at the Ikegami Lab, one must first understand how these researchers are part of cultural and historical reverberations, joining a crowd of scientists, who have grappled with the relationship of life’s form to matter and vice versa. If Ikegami and the lab members are engaged in reengineering and recoding the substance of life, so to speak, they are doing so in order to heighten their chances for determining its form. And as a very recent addition to the new sciences of the artificial, the lab members at the Ikegami Lab are tangled up in a cacophony of voices, which attempt to answer fundamental questions about life and the living. Joining the cacophony, however, the lab members ask a range overarching questions about life, old and new, among them, questions such as, “how did life originate?” “What is open-ended evolution?” “How do living things adapt, cognitively, to complex environments?”, “How do living things adapt, individually and structurally, to complex environments?” “What is intelligence?”, and so on. The many questions they ask at the lab, I suggest, gesture toward profound concerns about how life’s form, function, materiality, meaning and conceptuality, *might* hang together, by recoding life’s form and matter, by wriggling theory into substance, and substance into theory, by engaging in the process of distilling a fundamental belief that artificial life is “larger” than biological life.

Artificial Life and Anthropology

Since the field of artificial life officially emerged in the late 1980, when Langton drew it into coherence, a growing body of literature has emerged in the social sciences and the humanities, focusing on artificial life as a new hybrid field of art and technoscience (Whitelaw 2004; Johnston 2008; Helmreich 1998; Helmreich 2016; Kember 2003; Sengers 1998). Before, and concomitant with, the proliferation of such types of technoscience, many scholars of science and technology in the social sciences and the humanities have been exploring science as “culture” (Helmreich 1998; Fischer 2007) and as “technoscience” (Haraway 1991), focusing on the intricate and often complex relationships between technology and society, materiality and sociality. Many social science scholars, for example, have often worked from science and technology studies (STS) as a point of departure, with a particular interest in the co-shaping of knowledge, technology, culture, and society. Among such bodies of literature are also anthropological accounts, for example, which have taken to an understanding of such relations over an axis of duality to support the assumption that there are radical differences between worlds material and immaterial (see Chua & Salmond 2012; Henare et. al. 2007). Other anthropological accounts, on the contrary, have sought to dissolve strict boundaries between people and things (Gell 1998), humans and machines (Haraway 1991; Suchman 2007; Rabinow 2011), humans and nonhumans (Latour 1993; Latour 2005), things and concepts (Henare et. al. 2007).

But while the relations between people and things, humans and machines, humans and nonhumans, things and concepts, and so on, have been variously scrutinized by a number of anthropologists and philosophers of science, a range of social science researchers have since the 1970s also turned attention to those specific and localized knowledge production processes at work inside laboratories (cf. Latour & Woolgar 1979; Vinck 2007). In this body of work, STS-scholars Bruno Latour and Steve Woolgar (1979), for example, shifted ethnographic attention to those social processes, acts, and material arrangements that lead up to the ordinary production of scientific objects, traces and publications at work within the lab itself. Unlike previous studies, Latour and Woolgar were some of the first to conduct ethnographic studies of how laboratories, as localized social sites, operate to design and manufacture “facts”

(Latour & Woolgar 1979). Notably, they have shown how local conditions and social dynamics at the lab, including the production of “facts”, essentially aim to convince other researchers in other fields (cf. Vinck 2007:1).

But at the heart of this shift in attention to what Latour and Woolgar term “laboratory life” is sensitive attention to the, “social construction of scientific facts”, which are constituted at modern laboratories, and so, has to do with everyday practices at the lab. Thus, they give priority to those social forces and interactions, including writings, instruments and embodied skills, at play within the lab itself (Latour & Woolgar 1979). So, instead of focusing on knowledge itself, Latour and Woolgar focus on what knowledge does and illustrate how everyday life in the laboratory may give way for what they call “enrolments” and “actions” that organize and give meaning to their activities (Latour & Woolgar 1979). What will hopefully become apparent throughout this thesis, then, is that the construction of “facts” is indeed a networked activity since “facts” cannot be adequately established, nor legitimated, without a slew of social, historical and material possibilities. However, what I specifically hope to show is also that “worlds” and “worldviews” are not only products of networked activity – i.e. the result of an assemblage of materialities, writings, publications, instruments, embodied skills, historical possibilities, and so – but also products of a specific form of charismatic leadership. However, I will return to this point later on in this introduction.

For now, in relation to the field of artificial life, there has been a range of studies - including laboratory studies similar to those of Latour and Woolgar - conducted by anthropologists and social science researchers. In much of the literature directly related to artificial life, scholars have, for example, examined how new forms of nascent “life” emerge through new technical and material-semiotic infrastructures within human-constructed environments (Emmeche 1994; Risan 1997; Doyle 1997; Helmreich 1998; Sengers 1998; Ward 1999; Lansing 2002; Whitelaw 2004; Johnston 2008). One notable science scholar, John Johnston (2008), in *The Allure of Machinic Life: Cybernetics, Artificial Life, and the New AI*, have investigated the sciences of cybernetics, artificial life and artificial intelligence (AI), suggesting that research initiatives, such as the evolution of digital organisms, computer immune systems,

artificial protocells, evolutionary robotics and swarm systems have achieved a level of complexity and autonomy making such fields worthy of study in their own right (Johnston 2008). Focusing on the “objects at hand” – that is, the machines, programs and processes that constitute what Johnston calls “machinic life” (Johnston 2008) – he has shown how specific forms of nascent life emerge in and through technical interactions in human-constructed environments. But to track how such new life forms – or, in the words of Johnston, how new forms of “machinic life” – are nowadays actively brought forth by fields such as artificial life, he specifically proposes the analytic term “computational assemblage” to pinpoint underlying differences of form and function, as framework for understanding machines “as a material assemblage (a physical device) conjoined with a unique discourse that explains and justifies the machine’s operation and purpose” (Johnston 2008:x). However, Johnston has not conducted laboratory studies in any strict sense, (as those undertaken by Latour and Woolgar) he has nevertheless marked artificial life – including other sciences of the artificial – as new forms of technoscience, which may equally be items for ethnographic attention, especially in terms of how notions of “life” are constructed in discourse and in practice.

A few of those who have actually conducted ethnographic fieldwork at artificial life laboratories are anthropologists Lars Risan (1997), Stefan Helmreich (1998), and more recently Christine Aicardi (2010). All have published detailed monographs of artificial life, based on fieldwork experiences at the University of Sussex and the Santa Fe Institute for the Sciences of Complexity (SFI) during the 1990s and the late 2000s. In the late 1980s, the field of artificial life had just surfaced as a new hybrid field of computer science, theoretical biology, and digital gaming, devoted to mimicking the logic of biology in the virtual worlds of computer simulation and in the hardware realm of robotics. In the early to mid-1990s, Risan, for example, commenced his fieldwork among artificial life researchers and evolutionary roboticists stationed at the University of Sussex, UK, who then came to feature in his work *Artificial Life: A Technoscience Leaving Modernity? An Anthropology of Subjects and Objects*. In this, Risan show how the rhetorics of complexity and computational flexibility in artificial life allowed for an ecological and situated sense of the observer’s embeddedness in systems (Risan 1997). Following from his

observations that artificial life researchers were making “non-linear” computer simulations, expecting them to display “agency” in the sense that they hoped their simulations would surprise them or escape their control, Risan explicitly singles out a very specific cultural trait among them of “letting go of control”, what he sees as a defining characteristic of the relationship artificial life researchers have to their systems (Risan 1997).

In a similar vein, and roughly about the same time, Helmreich (1998), in his monograph *Silicon Second Nature: Culturing Artificial Life in a Digital World*, based on his fieldwork among artificial life researchers clustered at the SFI, argues that artificial life models, programmed by his interlocutors at the SFI, reflected the unconscious cultural assumptions and social prejudices of their creators (Helmreich 1998). Helmreich writes, “[...] Because Artificial Life scientists tend to see themselves as masculine gods of their cyberspace creations, as digital Darwins exploring frontiers filled with primitive creatures, their programs reflect prevalent representations of gender, kinship, and race and repeat origin stories most familiar from mythical and religious narratives” (Helmreich 1998:95). For Helmreich, the computational models and simulations produced by artificial life researchers during the 1990s thus revealed their own cultural backgrounds and psychological idiosyncrasies. But such are not, according to Helmreich, to be taken as theoretical pronouncements or evidence about the workings of the world, but rather to be taken as refractions about their creators’ own belief systems and modes of thought. “That many Artificial Life practitioners are white men who grew up reading cowboy science fiction”, Helmreich continues, “is not trivial” (Helmreich 1998:95).

Finally, many years later, Christine Aicardi (2010), who is trained in applied mathematics, argues in her dissertation *Harnessing Non-Modernity: A Case Study of Artificial Life* that, “the Artificial Life research community shares [...] a culture of ‘agency-rich’ simulation,” noting that their, “defining trait, their cultural ‘glue’, is the conviction that synthetic systems, which design involves computer simulations, is relevant to understanding life and its distinctive characteristics” (Aicardi 2010:15). Aicardi offers neither an ethnographic account nor a bird’s-eye view of a highly dispersed discipline, but maps and anchors the terrain of artificial life in a sort of

macro-study in an ethnographically-oriented portrayal of the Centre for Computational Neurosciences and Robotics (CCNR) at the University of Sussex. Here, she recognizes the importance of “play” among artificial life researchers, who play with their simulations in order to elicit agential interactive responses from their machines, “In a culture of simulation,” she writes, “it seems that objects-to-think-with are also objects-to-play-with.” (Aicardi 2010:68).

These monographs all take their outset in actual laboratory studies in the sense that both Risan, Helmreich and Aicardi have sought to explore the social and cultural terrain within the community of artificial life through the labs sites. This thesis is, needless to say, indebted to these ethnographies, specifically taking from them the approach of looking at how practitioners in the field of artificial life are social actors that bundle biological theories, concepts, ideas, and assumptions about life around the things they make. Yet, this thesis is also indebted to the work of Latour and Woolgar in the sense that such bundling together of words and things, theories and concepts, and so on, are not only tied to the materialities they describe, but they are also, as already mentioned, inextricably linked to social forces at play, indeed, as I will show in this thesis, to a special form of charismatic authority. In attempting to construct artificial life in the real world, then, so too are the researchers at the Ikegami Lab in the business of constructing and forward-engineering a culturally specific a world(view), an ontoepistemological framework that I call Ikegamianism through which to see the world and which they are in turn building into their artifacts.

In a historical and cultural moment when artificial life researchers are progressively being animated by the specific technological possibilities of their time, a time when technologies allow them to retool their commitments to worlds beyond the virtual domain of computer simulation, I am therefore curious not only to follow in the footsteps of previous anthropological accounts of artificial life, exploring how new unique discourses and narratives might emerge from the construction of new artificial life systems, but also to highlight some of the many implicit synergies between artificial life, cybernetics and anthropology.

Theoretical Scheme

Insofar this is an anthropology *of* artificial life, it is therefore, like its predecessors, a culturally and historically contingent account, in which new conceptual, material, and technological objects are being made and remade. As such, the new artificial systems developed at the Ikegami Lab may today not simply be seen to be tools for human convenience in the sense that they are made to serve practical purposes, for example, such as provide commercial services or to optimize economic or agricultural functions. Rather, the new technologies developed at the Ikegami Lab, I suggest, are material technologies with which to rework life's substance and thereby its conceptual definitions. That is, the things they make at the lab, as philosopher of science Hans-Jörg Rheinberger (1997) notes, are "epistemic things" – things that are situated interfaces between the material and conceptual aspects of science (Rheinberger 1997). Indeed, by yoking analysis to synthesis, or more practically, by using *technologies as tools for theorizing life*, the artificial life researchers featured in this thesis hope to yield a much more capacious sense of the term "life", not only in terms of what life *is*, but also in terms of what it might *become*. Artificial life technologies, in other words, are not only good-to-think-with, but also, I want to suggest, epistemic tools with which to think about life and revamp its definitions.

Now, if new artificial systems, constructed at the Ikegami Lab, are good-to-think-with, I am curious how those artificial systems they make at the lab – those developed by, emplaced in, and mobilized through, the social and cultural tapestry of the Ikegami Lab – come to function as epistemic things. In order to examine how newly-made artificial systems actually become what Rheinberger calls epistemic things, or what I call parallax machines, one must first understand how the Ikegami Lab is organized. To this end, I ask about some of the social, cultural, rhetorical, material and technological forces at play at the lab, for example, how the lab members make sense of their technologies and how they are useful for making sense of life. How, for example, do contemporary artificial life researchers – namely those at the Ikegami Lab – design, develop, construct, and employ new advanced technologies of various sorts,

both as a way to ask new, and yet-unasked, questions about life *and* as an end in itself? Or more precisely, how do the lab members at the Ikegami Lab use their self-made artificial systems to generate new or bolster current knowledge about life, voice fresh insights about (artificial) life, or articulate new theories of life? How might such new artificial systems be related to the lab's self-described mission to construct artificial life in the real world? And how might they ultimately be marshalled in the service of discovery science to authorize, legitimize or validate efforts to construct artificial life in the real world?

To work out this complex, my analysis is interlaced into two distinct, yet interrelated tracks that run in parallel – or, more aptly, in a parallax – throughout the entire thesis. On the one side, my interest lies in discerning how the “objects” of artificial life (that is, the new artificial systems they are constructing at the lab) become epistemic objects, or rather, what I prefer to call parallax machines. On the other side, I am equally concerned about what may be called the “project” (that is, the socio-cultural formation we know as the Ikegami Lab) in relation to what or whom constitute the social and cultural basis for constructing the objects of artificial life. Put differently, this means that I ask about how the local discourses, the social interplays between lab members, the culturally and historically contingent worldviews, ideas, values, motivations, beliefs and norms produced by the lab members and circulated between them, things, I believe, that lab propel the lab members into action. Thus, if the “objects” of artificial life refer to those specific material things artificial life researchers at the Ikegami Lab are building, the “project” of artificial life refers to the socio-cultural dynamics *and* the overall “ontoepistemological” orientation of artificial life. The object and the project of artificial life are entangled into one another and are therefore inextricably linked. Thus, the object and the project of artificial life must therefore, I hold, be examined and understood in relation to one another.

Objects and Projects, Ikegamianism and Parallax Machines

Because the objects of artificial life cannot be examined in isolation from the social forces underlying their creation, the first analytical track centers on the “project” of

artificial life. As noted, the project of artificial life refers to and include those social relations, interactions, cumulative micro-transactions, discursive strategies, performative and material practices, and forms of expertise that are at play within the lab. And so, insofar one regards the Ikegami Lab as an action system, in which lab members work individually and collectively to generate new insights about life, their efforts are, of course, streamlined and made sense of by a slew of micro-transactions, discursive strategies, performative practices, and forms of expertise. Thus, while parallax machines may be said to be themselves enthralling (partly because they are “real”, physical object that are both animated and lively, and indeed, as such allusive to the idea that technologies can be truly alive), they must, following science scholar Katherine Hayles (1996), be narrated to make sense, and such storytelling often employs themes and topics from researchers’ cultural worlds (Hayles 1996). The lab members, then, are variously engaged in making sense of their creations, whether these are computer simulations or embodied systems such as robots, and so they draw on a range of cultural and epistemic resources in order to explain their inventions.

However, in discerning the project of artificial life, and insofar practices at the lab are informed and motivated through social interactions, by a series of micro-transactions, discursive strategies, performative practices, forms of expertise, and so on, I specifically want to highlight how Ikegami himself is a central component to the project of artificial life. Ikegami, I found during fieldwork, is unquestionably an undisputed leader at the lab, as he takes the role of a sort of spiritual or religious guide among the lab members. Many lab members, for example, often described Ikegami as a “genius” and absorbed many of his ideas and concepts into their own work. Ikegami is arguably the “gate-keeper” of lab, one, who single-handedly decides who gets enrolled in his lab and who does not. And more importantly, he is a charismatic leader, who plot the overall philosophical, metaphysical, ontological and epistemological bearings of the lab. And so, while Ikegami is not the programmer of all the systems built at the lab, nor in direct control of all individual research projects, and while all the lab members still sometimes participate in situating their systems within their own narrative frames, Ikegami is undeniably a “point of passage” (cf. Law & Callon 1994) if one wants to understand the social dynamics at the Ikegami Lab.

Thus, Ikegami is an authoritative figure not simply because of his title as principal investigator and professor at the lab, i.e. by virtue of his title and official position, but also, I want to show, *because* he is a charismatic leader. Ikegami embodies, then, what sociologist Max Weber (1954) calls a form of “charismatic authority” (Weber 1954) - a form of authority and power, which is exclusively derived from Ikegami’s personal qualities and emotional posture; he is to the lab members, in other words, a creative, charming and seemingly trustworthy leader. Charismatic authority, as Weber says, is opposed to other forms of authority, such “traditional” and “legal” authority, is substantially unbounded by norms. And thus, unlike the other two forms of authority, charismatic authority derives its power and persuasiveness *through* personal qualities, for example, through charm or wit, which in turn generates “sacred norms” by word and deed (Weber 1954; Spencer 1970). To the lab members at the Ikegami Lab, Ikegami *is* artificial life, the very embodiment of the enterprise itself. And as such, he becomes a sort of prophet, who, they say, is a “huge source of inspiration” and a “creative genius”, who by his word allows him to, “destroy old norms and create new ones” (Spencer 1970:125).

Ikegami’s charismatic authority, then, is both a form of expertise and the primary force propelling the project of artificial life, i.e. Ikegami has become the center of his own cult of personality generating followers and zealots, who join his cause. To this end, I want to suggest that Ikegami, by virtue of his personal qualities, emotional posture and style of leadership, socially orchestrates the lab, and by doing so, he seeks to outline the contours a new scientific paradigm. By becoming the center of his own cult of personality, then, means that he is the author his own “culture” in the sense that he offers philosophical, metaphysical, ontological and epistemological guidance to his lab members. And as such, he is the author of the what I call Ikegamianism – a shorthand for the ontoepistemological framework by which the lab members operate, which include a set of beliefs, principles, norms and values to which the lab members adhere. My concept of Ikegamianism is largely, although not directly, inspired by feminist scholar Karen Barad’s (2007) own “ontoepistemological framework” she calls “agential realism” – a new philosophical framework that entails, she argues, a rethinking of fundamental concepts” that “provides an understanding of the role of

human and nonhuman, material and discursive, and natural and cultural factors in scientific and other social-material practices” (Barad 2007: 26). And so, what will hopefully become apparent in this thesis is that Ikegami, like Barad, is the author of his own ontoepistemological framework. The social structure at the lab, finally, then represents an emotional collectivization centering on Ikegamianism, which is held together, I argue, by an emotional bond with Ikegami, not simply by some formal chain of command, nor is it rooted in any kind of “traditional” or “legal” authority as such.

However, Ikegamianism is not a full-fledged and coherent ontoepistemological framework, nor a fully-developed paradigm in its own right. Rather, I want to reserve, Ikegamianism may be seen as an expression of Ikegami’s position at the lab and his desire to articulate new ways of doing science. In short, Ikegamianism is not only a shorthand I use for describing what goes on at the lab, but it is also expressive of Ikegami’s idiosyncratic aspiration to establish his own paradigm. And rightly so, Ikegami, I experienced during fieldwork, both implicitly and explicitly cast himself as a sort of Renaissance man, who feels he is on a mission to create a new mode of science, one strongly influenced by an artistic and unorthodox approach. Indeed, together, Ikegami and the lab members feel they are pioneers on a mission to change science altogether. And as the ganglion of his network of zealots, to use a more religiously-inflected language, Ikegami motivates belief not only in the project of artificial life at large, but he also becomes a sort of prophetic, spiritual or ethereal leader, whose “creed” (Ikegamianism) creates “believers”.

Now, the object of artificial life, I hold, cannot be separated from the project of artificial life: Ikegamianism, as a charismatically-certified ontoepistemological framework is closely tied to the practices of constructing parallax machines and thus cannot be separated from one another. This is exactly because Ikegami defines the overall philosophical, metaphysical, ontological and epistemological orientation of the lab and thus the one who set the goals. And as a charismatic authority, much of the work done at the lab is propelled by a collective belief that they are indeed on a collective mission to change science altogether. What I want to show is that parallax machines, then, become physical manifestations of Ikegamianism, that is, material

residues of the social forces at work at the lab and Ikegami's self-constructed creed, or even, perhaps, material reincarnations of Ikegami himself².

The concept of parallax machines is of my own invention, indeed an etic term meant to capture how Ikegamianism is given material expression through the artificial systems they make at the lab. Parallax machines, to this end, denote those physical and material things, such as robots, that they construct at the Ikegami Lab. And so, parallax machines, I want to show, do a lot of work for Ikegami and the lab members, such as, for example, bolstering belief among people, both inside and outside artificial life, in the possibility and realization of artificial life, as a special form of life. However, more importantly, parallax machines also have parallax capacity by which they 1) embody and give material expression to Ikegamianism and, I want to show, 2) invite us to see “life” through a parallax view, a view where life is *simultaneously rendered artificial and biological*. Such a view, I hope to show, is first and foremost inseparably tied to the material construction of parallax machines, and, as we shall see later, these machines allow artificial life researchers to stretch and amplify the gospel of Ikegamianism.

Setting: The Ikegami Lab

About 15 researchers constitute the core group of the Ikegami Lab, yet none of them are originally trained as artificial life researchers. Rather, all of them are émigrés from other fields - computer science, neuroscience, artificial intelligence, machine learning, biology, mathematics, physics, complex systems science, psychology, electrical- and mechanical engineering – who self-identify as “artificial life researchers”. Officially, they call their lab an “artificial life laboratory”, and the lab itself is the base at which both national and international lab members, holding different degrees and positions - professors, postdocs, PhDs, external members, and graduate students – congregate to undertake the work of artificial life. Some of them have migrated to Japan from

² Of course, this is an overstatement, but I want to stress and accentuate how Ikegami becomes a sort of demigod to his followers, i.e. the lab members and other curious souls outside the field of artificial life, for example, such as external collaborators and artists. The Ikegami Lab is, in some way, Ikegami himself, the hotbed of his cult, an enterprise, I believe, which may be read and understood largely as analogous to a sort of spiritual or New Age movement.

institutions in Europe - particularly from Belgium, France, Germany and the UK – while only a few come from other Japanese academic institutions, such as Tsukuba University, Kyoto University and Tohoku University. Others have been trained at some European university, doing a layover at a Japanese university, before ending up at the Ikegami Lab. Unlike myself, most of them are trained as computer scientists, who have, after their training, turned their attention to the field of artificial life. After graduating, all of them left their native disciplines and clustered at the Ikegami Lab in order to pursue their research interests (which mostly differ from those of their native disciplines) in exploring a slew of topics and questions related to the study of life.

Although each lab member differs slightly in terms of academic backgrounds, some coming from engineering and others from computer science and only a very small handful from biology, they have different skillsets, and even different research agendas. What is practically common among them despite their educational and academic differences, however, is that they all share an interest in discerning, as they say, “what life is”. Of course, this somewhat generic question, “what is life” may be a sort of working title or universal aspiration among all artificial life researchers, but each of them, in getting at this hazy question, are bringing with them their own set of expertise: programming techniques and engineering strategies, soldering techniques, knowledge on quantum physics, thermodynamics, biology, and so on.

In a word, then, the lab members are therefore of international and interdisciplinary mixing, which many of them celebrate as an important key characteristic of the lab. This international and interdisciplinary mixing, however, is further complemented by a slim intergenerational mixing: the graduate students are in their mid- to late twenties, whereas the senior staff, such as assistant professors and professors, are in their late thirties or forties. The bulk of the lab members grew up in the 1990s and only a handful of them - those in senior positions (such as professor Ikegami, who is, in fact, the only professor at the lab) – grew up in the 1970s and 1980s. Thus, most of the lab members were my age (in their late twenties or early thirties) and we were roughly at the same stage of our academic careers. We were more or less dressed the same, casual apparel, sneakers and a cuddly sweatshirt, wearing a backpack with a laptop inside and growing up playing video games. About half of the lab members are

born in Japan, while the other half have come to Japan from other countries. The main languages spoken at the lab are Japanese and English.

The organization of the Ikegami Lab, to this end, is not that different from, say, how labs are organized at the IT University. And being used to this sort of academic environment of international and interdisciplinary mixing, with English as a baseline language of communication, my presence among them in terms of appearance and social affiliations in academia did not make me stick out. None of the lab members, I found during fieldwork, seemed surprised about the fact that an anthropologist had suddenly joined their ranks. Rather, they were quite easy-going and felt comfortable socializing across our academic and international differences. Indeed, the fact that we have our backgrounds in higher education, the fact that we are all pursuing academic careers, and finally the fact that we are all part of an international academic community (imagined or not), I think, made us closer to be “colleagues”, if not “peers”, rather than “strangers”.

Now, however, while the 15-some lab members constitute a mottled crew, who all share collective reverence for Ikegami and an interest in putting their knowledge and skills to work in the equally mottled field of artificial life, it is also a field dominated by men and masculine ideals (cf. Helmreich 1998)³. Indeed, that I am a white, middle-aged Danish man with an academic background correlates well to the social demography of artificial life, and the Ikegami Lab is no different, composed mainly of men. This might have impacted my chances of getting access to the lab, seeing that I match the profile of an artificial life researchers quite well, assimilating easily into the demographic of the field. Lana Sinapayen, a PhD fellow at the lab, and Mizuki Oka, a computer scientist from the Tsukuba University and an external member of the lab, are the only two women at the lab. We never really addressed issues concerning

³ Anthropologist Stefan Helmreich (1998) notes that symbolic associations to masculine creation are strong in artificial life and writes that, “Imagery of a masculine monogenetic creation is not only present in the texts, programs, and publicity of Artificial Life, it also surfaces in the researchers’ casual comments, jokes, and, occasionally, their confessions about why they work in Artificial Life at all” (Helmreich 1998:215). According to Helmreich, some artificial life researchers, for example, claim to have a certain “grandfatherly pride” in a computer program. Although Helmreich believes it would be a stretch to argue that artificial life is ultimately driven by a masculine envy of women’s “ability” to birth, artificial life is, “predominantly the work of men [which] is crucial to how frequently and easily images of a masculine god are used” (Helmreich 1998:216).

gender or the gendered dimensions of their work or artificial life⁴, and the relationships I was able to build with my interlocutors were mostly, if not always, grounded first and foremost in our mutual recognition of each other as academics and professionals, and so, our shared interests in science, philosophy, literature, music and games initial launching pads to establish mutual bonds, but I will get back to this in a moment.

The Physical Location of the Ikegami Lab

The Ikegami Lab itself is physically located at Komaba Campus, one of five campuses comprising the University of Tokyo. Wedged into building 3 in the northwest corner of the campus, the lab is an unassuming single room furnished with a whiteboard, bookshelves, sofas, office desks, and computers, resembling any typical office space in any modern university. Although unassuming, a small welcoming sign next to the doorway reads, “Ikegami Lab: Open Laboratory”, under which someone has written in English with a marker pen, “Hello! Come in!!”, reflecting an open attitude and a welcoming vibe. Inside the lab, a large window panel pans over the baseball fields outside to the north, illuminating the office space, which is itself furnished with office desks, sofas, bookshelves and whiteboards. In the center of the room is a whiteboard, overwritten with signs and symbols, flow charts, arrows and intricate mathematical equations, surrounded by two sofas and a table, where the lab members occasionally convene to discuss their research or eat lunch. Squeezed tightly along the walls are the office desks - individual workspaces - cluttered with the personal belongings of the lab members: opened books, keyboards, cables, gadgets, lunch wrap, empty bottles, lighters, cups, mugs, and stacks of paper.

In the lab, the most prominent “scientific tool” in evidence was the computer, or more specifically, the lab members’ own laptops. These were, I noticed, their primary work tools, although many of them also dabbled with VR-systems and other electronic gadgets. However, these were typically unrelated to their research. To this end, there

⁴ See Helmreich (1998) for more about gendered relations in artificial life. This might, of course, also have impacted what sort of data I was able to generate. However, at no time during fieldwork did any of the lab members address the gendered aspects of artificial life, nor the fact that 90% percent of them were men.

were no robots, petri dishes, microscopes, chemicals, or anything commonly found in a wet lab. On the contrary, the lab itself was as dry as it could be. And so, on an everyday basis when I was at the lab, the atmosphere was usually calm and quiet with only the sound of the air-condition and the tapping of keyboards humming.

I was at the lab at least three days a week, every week, and most of the time I was there only about two or three lab members were in simultaneously. Lana and Julien Hubert - a trained computer scientist from the Vrije Universiteit Amsterdam and a post doc at the lab – had daily routines at the lab. Others, such as Ikegami and Yasuhiro Hashimoto – an assistant professor, were not exactly in the lab, but usually in their offices nearby. Doi Itsuki, Atsushi Masumori, Norihiro Maruyama and Hiroki Kojima – all PhD fellows at the lab – were rarely in the lab itself, but preferred to work from home, from the library or elsewhere, scattered around campus. On any given time, Yasuhiro would stop by the lab with cookies, a lab member would go see Ikegami in his office, or I would unexpectedly run into, say, Norihiro or Hiroki in the hallway. And this pretty much characterizes the dynamics at the lab, lab members coming and going on a more or less irregular basis depending on their schedules: some, like Yasuhiro, were often teaching classes, others, like Norihiro, were trekking in woods outside Tokyo⁵. In other words, that is to say that the lab members were not handcuffed to their office desks, nor had a fixed time at the lab, and so their work routine was not necessarily bound to the lab itself. Obviously, this hampered my chances of seeing them all, as I would have to make very specific appointments if I wanted to, say, do an interview or simply just having a chat.

However, that said, one of the main collective institutions at the lab is the bi-weekly lab meeting. Every second week, all the lab members assemble, either at the lab (building 3) or on the ground floor of building 16 – a large, 8-story concrete building next to building 3 – to collectively keep each other updated on new research, both inside and outside artificial life, and to discuss matters related to artificial life. These meetings formally consist of three segments and are usually resolved within two hours or so. In the first segment, the lab members review and analyze state-of-the-art

⁵ To be fair, this is not to say that Norihiro was not at the lab, nor that he was not an integral part of the lab, but only that he spent his free time as an outdoorsman. It will perhaps, then, not come as a surprise that his research focuses on in relationship between the “mind” and the “open environment”.

and cutting-edge literature, not only the field of artificial life, but also in fields such as machine learning, artificial intelligence, philosophy of the mind or biology, to name only a few. At each meeting, a single lab member is assigned to do a review and then present her own reading of the practical, conceptual or theoretical significance of the chosen article to the other attendees. During fieldwork, this segment would be used to establish a basis for the following discussion of the paper at hand, where lab members exchange perspectives and pitch new ideas in relation to how the articles may or may not relate to their own work. For example, one day, a lab member presented an article, originally published at a machine learning conference (Proceedings of the 35th International Conference on Machine Learning, [ICML2018], in Stockholm Sweden), about training plastic neural networks with backpropagation⁶.

In the second segment, one lab member, chosen by Ikegami, is assigned to update the other lab members on their individual research projects. Here, the lab members are not necessarily required to relate the preceding review to their own research, but rather to provide the other members with an overview of the progress of their own research, for example, in order to spark fresh discussions or reactions that may be constructive to their further work. Lastly, in the final segment, when the reviews and presentations are over, the format of the meeting turns into a loose, informal collective discussion about a variety of topics, for example, such as discussing questions and problems related to thermodynamics or Black Swan Theory⁷. As one lab member told me, the final segment of the meeting is a forum, where they collectively, “toss and throw” different, sometimes unrelated, ideas and concepts “at one another” to hatch new ideas in relation to their research. Such “tossing” and “throwing”, I learned during fieldwork, was meant to ask open questions on how, for example, to train artificial neural networks, how to learn how to learn, or how to

⁶ The specific article in question was published by computer scientists Thomas Miconi, Jeff Clune, and Kenneth O. Stanley (the latter, who will also feature later in this thesis), who ask in their article how to build “agents” – i.e. virtual agents – that keep learning from experience, quickly and efficiently, after their initial “training”. The appearance of articles of similar content were, needless to say, not uncommon during lab meetings, as the lab members had a tendency to favor scientific papers from conferences and journals in the fields of machine learning, artificial intelligence, physics, mathematics and computer science. In fact, most of the articles I encountered during lab meetings were published in computer science journals and conferences.

⁷ Black Swan Theory is a metaphor that describes an event that emerges as a surprise, and has a major effect, but is often (inappropriately) rationalized after the fact with the benefit of hindsight. It is, perhaps, not surprising that such a theory is of interest to those who embrace “serendipity” and “surprise” as positive qualities to their research, indeed, as favorable outcomes of their work.

define “gliders” – those digital patterns that travel across the board in John Conway’s famous cellular automaton “Game of Life”, which will also feature later on in this thesis. To this end, the bulk of collective and social activities were undertaken during the bi-weekly meetings, whereas the lab members’ individual research was undertaken only by a few members at the lab on an everyday basis.

A Note on Method

The empirical basis of this thesis is grounded on ethnographic fieldwork first conducted from February 2017 to June 2017, and later from February 2018 to May 2018, a total of 7 months. However, in fact, my fieldwork began much earlier, in 2016, when I came to the IT University of Copenhagen from the Department of Anthropology at the University of Copenhagen. When I arrived at the IT University, I had brought with me an interest in “multispecies ethnography” (cf. Helmreich & Kirksey 2010), and I had grown increasingly curious about the “multi” in “species” and the limits of the notion of “species” itself. What did it really mean to conduct “multispecies ethnography”? As a quite recent turn in anthropology, I still had the impression that this was merely another intellectual gimmick undergirded by other recent anthropological turns to the “nonhuman” and “ontology” (cf. Henare et. al. 2007). Thus, my initial concerns about the topic was whether this was merely some gimmick or whether it was some substantial and radical departure from established modes of doing anthropological research. Whatever the case, and more significantly, if multispecies ethnography was a call for anthropologists to attend to domains beyond the human, what could be included in the term “species” especially in times when 21st-century transhumanists have begun proclaiming that they were now seeking to radically reengineer the “human species”, or when new constellations of technoscience, such as synthetic biology or artificial life, are actively reconfiguring the substance of life, putting pressure to the organic world and to its inhabitants? Particularly, I thought, what could “species” then mean in times when synthetic biologists, for example, engaged in remaking the category itself through the material constructing new biological chimeras?

I came to the IT University fresh from writing about how oceanographers, biologists and fishermen along the Maine coastline, US, sought to steward the sea and its inhabitant - or “species”, human and nonhuman - through making models of it. However, along the way, after finishing my thesis, it had come to my attention that artificial life researchers had spent a good two-decades trying to model something of equal, if not surpassing magnitude: life and the living. If oceanographers, biologists and fishermen in Maine were engaged in efforts to somehow account for the sea and its inhabitants by modeling it, it artificial life researchers were somehow, perhaps in similar ways, engaged in efforts to account for life and the living by modeling it. How would such efforts, I initially thought, form, reform or deform the notion of “species” and ultimately the notion of “life itself”? Moreover, if “species” denote those biological and embodied bits of vitality we also know as “organisms”, human and nonhuman, how does one model “life”? Indeed, what is “life” – a concept, a thing, a word? – and what is “artificial life” to those who believe that life can be materially and conceptually reconstructed?

Now, a lot has happened since, and to cut a long story short, I launched into a project to study the complex field of artificial life in hopes of learning what kinds of hybrid “boundary objects” (Star & Griesemer 1989) would take shape in linking computers to biology, computational metaphors, code and information to biotic things? It was not the first time I had encountered attempts to use “artificial” means to model “nature”, linking “culture” to “nature”, the natural to the artificial. Oceanographers, for example, had been doing computational modelling work at least since the 1980s. But what did the “artificial” in artificial life even mean, and what is artificial about artificial life, using artificial means to create the artificial? That is, off the cuff, for an anthropologist, what cultural residues could be read into artificial life, as a sort of Promethean aspiration to somehow create “life” artificially, and what could this tell us about the notion of “life itself” in our contemporary moment when life is not simply believed to be a natural category, something to speculate about, but something to be modelled, engineered, and constructed?

After learning about the existence of the Ikegami Lab from doing targeted web searches, and later by emailing Ikegami himself, I became curious what Ikegami

meant by his self-described mission to, “construct artificial life in the real world”, including his claim that, “artificial life is larger than biological life”. Upon this concern, as anthropologist Marilyn Strathern (1992) notes, I came to take note that the “artificial”, as it pertains to “artificial life”, hints at the undoing of “life” as a “natural kind” (Strathern 1992), but what does it mean to construct artificial life in the “real world”? To construct new artificial life forms (i.e. robots, machines, or other abiotic things composed not of biological materials but of silicon and other synthetic materials etc.), to construct the field of artificial life itself (an epistemic community, a new social formation of life scientists etc.), or to construct or reconstruct the concept of “life” altogether? Furthermore, following Ikegami, what is the “real world”? In the meantime, from other anthropologists, I learned that the field of artificial life had a strong tendency to favor using computers, as their primary scientific instruments, both to “synthesize” and make “simulations” of things they associate with life and the living (cf. Risan 1997; Helmreich 1998). Thus, if artificial life centered on an exploratory computer-simulation-based way of working, a practice embedding its theoretical target, “life”, firmly in a computational and digital realm, what would the “real world” then refer to? And in this relation, what did Ikegami mean by his acutely direct mission statement to, “construct artificial life in the real world”?

The Zealots of Ikegamiism: A Countercultural Movement

Anthropologists of science and technology have taken note that technoscience - the “time-space modality” that exceeds, “the distinction between science and technology, as well as those between nature and society, subjects and objects and the natural and artifactual that structured the imaginary time called modernity” (Haraway 1997:3) - must be examined and known not only in relation to their specific theoretical frameworks to which it is tethered, but also as socially located discourses and practices, merging into what may be termed as “culture” (see Pfaffenberger 1992; Traweek 2000; Fischer 2007). At the Ikegami Lab, a bunch of people with very different backgrounds have come together from many different places under the aegis of artificial life. However, they do not constitute some homogenous and fixed “culture”; they see themselves as a sort of movement, a countercultural movement on a mission to change science. But insofar they are all migrants from other disciplines,

and while they have many different interests and research agendas, what then might constitute their sense of community, their sense of belonging? In other words, what, despite their many differences in terms of nationality, academic background, age, gender, research agendas, skills, technical abilities, do they actually share, besides the fact that they call themselves artificial life researchers?

What created a structure of feeling among them a sense of unity, I later realized, was not simply the fact that they all self-identified as artificial life researchers, but a shared admiration of Ikegami himself. Ikegami plays a central role at the lab, taking the role as a sort of spiritual leader. During fieldwork, Ikegami, it appeared to me, had seemingly orchestrated an entire community around himself, and as such, acted as the intellectual beacon and the “face” of the lab, he was, and still is, the spearhead of his movement. Overall, Ikegami is the one charting the epistemic bearings of the lab and the one attracting both academic, artistic, and public attention to the field of artificial life, including anthropologists like me. Not only the principal investigator and head of the lab, but also the one who selects and chooses, single-handedly, who becomes enrolled or not, Ikegami is the one who “calls the shots”, and as such, this is also part of the reason he popped up on my radar. His visibility as a public figure quickly captures your attention, and once you get to know him, you realize that he polices the disciplinary boundaries of artificial life ferociously and the one, who establishes and manages collaborations with other academic institutions and people around the world.

My first impression of Ikegami, roughly by the end of my first field trip in 2017, was that he was strict leader, one who demanded a high level of individuality and ingenuity from the lab members. I recall one person from a workshop in Osaka⁸, for example, who told me that he had applied to enroll at the lab, but he quickly found, during a “job interview”, that, “Ikegami-sensei did not like my ideas”, and he was immediately rejected. He later told me that Ikegami was that type of person who either likes you or not, depending on how “creative” you are in your thinking. Back at the lab a few weeks later, a lab member described his relation to Ikegami, saying that social relations at the lab were like, “chemistry,” noting that,

⁸ During fieldwork in 2017 and 2018, I took a few trips down to Osaka from Tokyo to arrange and attend anthropological workshops at the Department of Anthropology, Osaka University. Some, but not all, of these workshops were based on data and topics from my own fieldwork.

The chemistry between people at the lab is very important, but it doesn't work with everyone [...] Takashi has a very special personality, he's not very 'Japanese-like', and that doesn't work with everyone. You need to be super autonomous and creative on your own, disciplined, because he's the main source of scientific ideas, he's super creative, but if you're not able to lead a dialogue with him then it'll be hard to take advantage of and build on. He lets you free, and for people who are not very disciplined, it's very hard to get a PhD. So, it didn't work for everyone.

Many lab members, too, often described Ikegami as demanding much "discipline", with many regarding him as a sort of creative prophet or some inspired teacher, who was also a "main source" of scientific ideas. Also, the fact that social relations were by lab members described in terms of chemistry meant for them, and other hopeful apprentices like the reject I met in Osaka, who aspired to join the lab, that the chemical composition (read: the network of social relations) would have to be in order. It either works or not, you either fit into a fixed arrangement or not, also reflecting, I think, how Ikegami is the one running the show.

During fieldwork, though, it nevertheless became clear that Ikegami was not only mediating access to his field, but he was also someone you needed to impress in order to grab his attention. For example, I felt this struggle for his attention during some of our conversations, where Ikegami would turn almost lethargic if he felt my ideas were too banal or clichéd. I often felt that he clearly expected of me to think more radically or to be creative, and this is also what he expects from his lab members. To them, he is an inspired teacher, and indeed, many of the lab members cherish his visionary outlook, his eclectic and multidisciplinary approach to artificial life and the study of life. "Takashi," one lab members tells me, "is a generalist, he does everything Alife. He's really an artist."

But so too is Ikegami the one who establishes collaborative relations outside of his own lab. For example, the Earth-Life Science Institute (ELSI)⁹ at the Tokyo Institute of Technology, where some of Ikegami's former students had also later managed to get employed as assistant researchers, have become one of their main collaborators. During fieldwork, I got glimpses of how Ikegami also did joint collaborative research projects with so-called "external" lab members, for example, at the University of Tsukuba. These "external" lab members are not officially part of the lab, but have specific interests in the field of artificial life, but are equally fascinated with Ikegami. From time to time, Ikegami works closely with artists from Europe – from France and Germany – and Japan on "science-art projects" – projects, for example, in which they collectively work to express and communicate scientific points by artistic means. Ikegami would "hire" artists and collaborate with them to push artificial life into the domain of art, mainly the subcategory of New Media Art – a branch of art in which artworks are created with new media technologies, including digital art, computer graphics, computer animation, virtual art, Internet art, interactive art, sound art, video games, robotics, 3D printing, biotechnology, and more. Art, in other words, are an integrated part to Ikegami's vision of artificial life altogether, which I will also explore later in this thesis.

As part of the lab's international outlook, the lab members also attend conferences and workshops abroad – usually conferences and workshops on artificial intelligence, artificial life, physics, complex systems and computer science¹⁰ – at which they also sometimes provide keynotes on their own work. This, needless to say, it quickly became apparent to me during fieldwork that the Ikegami Lab extended beyond the physical boundaries of building 3, and that Ikegami's network of collaborators was vast. However, what was nonetheless clear was that Ikegami had built a community

⁹ The Earth-Life Science Institute is an established independent permanent scientific research institute based at the Tokyo Institute of Technology in the Meguro ward of Tokyo. It has more than 70 international scientists employed from a range of disciplines, ranging from astrophysics, chemistry, to synthetic biology and artificial life, who perform collaborative research on the broad connections between the origin and evolution of planets and life. The artificial life researchers employed fit well into ELSI's overall way of working, providing computational skills to the work of modelling evolutionary processes and more.

¹⁰ For example, the Conference on Collective Behavior in Trieste, Italy, 2018, the Open-Ended Evolution Workshop in York, UK, 2016, or the ALIFE 2018 conference in Tokyo, Japan, 2018.

around himself, enrolling a movement of zealots around himself. This, in turn, prompted me to “make the cut”.

Making the Cut

Anthropologist Matei Candea (2007) has made an appeal to “make the cut” (Candea 2007:174), by which he encourages fieldworkers to recognize “the value of limitation” (Candea 2007:180). Making the cut, in retrospect, became a useful methodological tool in defining the contours of the field, which simply meant chose to focus on the actual physical location the Ikegami Lab itself. At least to begin with, as a hub from where I would attempt to follow their activities outside the field. In retrospect, then, the fact that Ikegami is the main character of the lab, if not an embodiment of the lab itself, made it somewhat easy to “make the cut”. Of course, given the time frame, the focus of my research, and the economic circumstances of my research, it made sense to make the cut, since I was not able to travel with my interlocutors to international conferences or workshops. But, on the contrary, this in turn felt less important insofar my attention had to be directed at Ikegami himself, as a charismatic leader. Yet, that said, I did occasionally manage to attend art exhibitions, concerts, and public meetings around Tokyo, and attending such events were of course also vital to better understand the work of the lab, for example, as conduits for communicating their work to wider publics.

Now, “making the cut” is simply a convenient and highly practical tool to curb and contain the sprawling network of artificial life. Making the cut during fieldwork, though, allowed me to focus on the localized laboratory practices at the Ikegami Lab, which included registering the people populating the lab, and how their work was informed by a range of epistemic worlds reeled from both inside and outside the field of artificial life. This also simply meant to recognize the “value of limitation” in attending to how these people were first and foremost social actors, situated in real spaces, structured by complex face-to-face interactions and relations, and acknowledge that Ikegami constituted the “social glue” of the lab. But as such, it also meant that I could attend to how local discourses were established and maintained through everyday practice at the lab, namely through the work of leadership.

Making the cut, then, became a primary way to limit my scope during fieldwork, but also afterwards when writing this thesis, enabling me to follow more closely how local laboratory practices, which involve the social dynamics and actual, hands-on making of simulations, models, and other forms artificial systems, such as embodied robotic systems, would potentially inform, and be informed by, worlds beyond the lab itself. But more specifically, in doing so, I latched on to Ikegami and his position at the lab and took my outset from him. This took me from the physical location of the lab itself to music clubs and concert halls to art exhibitions and experimental sites around the city of Tokyo, to worlds to which the Ikegami Lab is tethered. Yet, the focus remained on Ikegami and the lab itself, as I followed the daily work at the lab, doing participant-observation and interviews with as many lab members as possible.

If making the cut made way for delimiting my field, it transformed my field into what anthropologist Ghassan Hage (2005), describes as a, “single geographically discontinuous site” (Hage 2005:463), by which the lab members actively assemble a unifying “culture” – or movement – not only across a number of global locations and across a multitude of epistemic domains, but also around Ikegami himself. All the lab members, I experienced when I attended lab meetings and when I did interviews, for example, often eclectically drew on epistemic resources from other fields, such as biology or computer science, to explain their work. But it was also clear from their descriptions and their motivations to join the ranks of artificial life that Ikegami, as a “genius” and “main source of inspiration”, had somehow persuaded or convinced them to become artificial life researchers. In this sense, many lab members echoed Ikegami, for example, by priding themselves on their scientific and epistemic eclecticism, seeing their own field of artificial life as able to take on a much broader perspective, a more holistic one, having a highly agnostic attitude to various and heterogeneous scientific and epistemic traditions. In short, they were trained to see themselves as sort of intellectual vanguard, a movement of rebels, who worked together against an established order. And this collective identity, I dare say, is one fostered and cultivated by Ikegami himself.

Thus, to go back to Hage and his own experiences among Lebanese migrants, he boils down the problem of doing what anthropologist George Marcus (1995) has called “multi-sited” fieldwork – the encouragement of fieldworkers to move beyond the bounded field site in order to deal with an interconnected world system (Marcus 1995) – to a question of choice, or, rather to a matter of making the cut yourself. It is necessary, Hage writes on the basis of his own fieldwork, to make a choice between emphasizing, “the migrants’ transnational culture at the expense of their settlement culture, even if, as is clearly the case, one cannot be understood separately from the other” (Hage 2005:467), and so, in relation to my own fieldwork, I chose to focus first and foremost on the lab itself. As such, my I was not so much doing what Marcus calls “multi-sited” fieldwork - even though lab members at the Ikegami Lab partake in activities beyond the lab itself, such as attending international conferences or drawing on epistemic resources outside their field - but rather the opposite: I centered my attention on *one* “culture” (cf. Hage 2005), one that bundles up an interconnected world system. Or, more precisely, while this is overtly my own construction of the “field”, as a single geographically discontinuous site, I chose to focus on Ikegami as obligatory point of passage and a seat of connections in discerning the Ikegami Lab itself.

Access and Position

At the Ikegami Lab, I had access to all areas of the lab: the office space, the labs, the library, and the other single-room offices distributed across campus. Normally, I would spend about 3 or 4 days a week at the lab, located in building 3, together with a few lab members. Here, I would frequently accompany them to eat lunch at the campus cantina, buy stuff at a nearby convenience store, or simply take strolls on campus in the fresh spring air. After hours, although less frequently, I would also sometimes join some of the lab members at bars, cafeterias or restaurants to have dinner or drink beers, or both. During my stay, I had no official status at the lab, no formal affiliation, yet my role as a foreign visitor did *not* really become that of a “non-person” (cf. Gammeltoft 2003:277). By “non-person” I specifically refer to the position of the researcher, or the ethnographer, as an outsider. So, while I was the first anthropologist to actually conduct ethnographic fieldwork at the lab, many of the lab

members had worked with anthropologists before in other contexts, and so I was not an outsider to them as such. However, not being officially enrolled as a lab member might have made me an outsider in terms of not being fully committed to their cause. But in spite of this, I was among the lab members, who were largely the same age as me, one of their own - a PhD student buried in his own work, just like them, the only difference that I was gathering my data among them while they were gathering data on their computers.

As already mentioned, my informant group consisted largely of men, something, which did not come to me as a surprise (cf. Helmreich 1998). Such gendered relations should, I believe, here be acknowledged in terms of access and position, as the lab itself consisted mostly of men. I positioned myself among the lab members as a sort of friend or colleague, who was genuinely curious about their work (something they were happy to share) and who offered professional and academic closeness rather than personal intimacy. However, my professional relationship to some lab members gradually lapsed into a personal relationship, which resulted in a budding friendship. But although being peer in terms of my academic background, my profession as an academic, my gender and age, I was never fully assimilated into the lab as such: I was still not formally enrolled in any research project and I had no formal obligations to fulfill. Yet, still not completely “inside”, I represented for the lab members an open and curious person, who was willing to discuss all sorts of questions and problems, which I believe made many of them comfortable in my presence.

That said, while fitting into the social demography, I tried to the best of my ability to make myself useful, not only as a partner in conversation, but also by helping them do proof readings of scientific articles, or simply by helping them move stuff, like cables, computers or robot parts for setting up experiments. While being a useful and practical asset to their work, as compensation for my incompetence in the art of programming and my lacking ability to fully comprehend the technicalities of their work, I quickly exposed myself as a novice in the field of artificial life. While fitting the profile of a typical artificial life researcher (cf. Helmreich 1998), my ineptitude in technical matters and the nomenclature of artificial life and programming languages clearly marked me off as a novice in the field of artificial life: I was unable to read

and write code, unfamiliar and unaccustomed to intricate biological concepts, to ongoing scientific controversies in the field of artificial life, computer science, ignorant of sub-fields such as “the origins of life” and “open-ended evolution”, and so on.

In the beginning, some lab members thought I had been enrolled at the lab to articulate, bolster or enhance new theories or contribute to current debates in the field. Others knew from the get-go that I was a visiting scholar and remained aware that I was doing ethnographic fieldwork and not necessarily doing studies for artificial life. Those who had the impression that I was at the lab to contribute “anthropologically” to their work and to the field of artificial life were often happy to discuss how anthropology could potentially contribute. They often equated anthropology with cultural studies, and sometimes wanted to discuss the concept of “culture”, however, not in any sense I had done before, seeing culture as a large “feedback system”, a cybernetic system keeping organisms in sync with their environments. Such talking across shared concepts meant that we were often able to speak and talk across concepts and disciplinary boundaries, which further bolstered a sense of social and academic coherence.

From socializing and chatting with lab members on a daily basis spoke, it least with those who were in, and by following them around campus and the city of Tokyo, it became apparent to me that all of them spoke highly of Ikegami. But my relationship to Ikegami, however, was different from my relationship with the lab members: my relationship to lab members, as peers, was more leveled, while my relationship to Ikegami, on the contrary, was more hierarchical in the sense that he treated me more like a neophyte with the potential to be converted. More precisely, while my relationship to the lab members remained collegial and somewhat equal, my relationship to Ikegami vacillated between us being peers exchanging ideas and Ikegami being a missionary trying to convert a heathen. However, while this was the case, Ikegami and I also found that we had many mutual interests, among other things, in literary preferences, philosophical works, and taste in movies. For example, in between interviews, we spent much time discussing the literary works of Ryūnosuke Akutagawa, Osamu Dazai, Kenji Miyazawa, the philosophical works of

Gilles Deleuze and Henri Bergson, or film documentaries like Johan Grimonprez' *Dial H-I-S-T-O-R-Y* (1997). Such mutual interests undeniably created a great sense of rapport between us, and made it easier for me to construct a healthy relationship to Ikegami, despite the fact that I was sometimes the neophyte apprentice to whom Ikegami felt a sort of fatherly or paternal pride in teaching.

Now, however, the internal personal relations between Ikegami and the lab members, I experienced, seemed to some extent be an echo of my relationship with Ikegami. The lab members, in other words, had been converts turned into followers or zealots. This is not to say that they followed Ikegami blindly, but simply that Ikegami's charismatic aura had drawn them into his world. Meanwhile, the lab members' internal relationship to one another seemed relaxed and somewhat informal despite the formal hierarchy often found at Japanese universities and Ikegami's position as a sort of paternal figure. Yet, all the lab members were friendly and jovial around Ikegami, and any now and then, Ikegami would, for example, either invite us to some microbrewery in Shibuya, close to campus, or join us at some izakaya (casual tavern/bar) somewhere in Tokyo.

This sort of structured, yet relaxed interpersonal relationship between Ikegami and the lab members generally gave me the impression that the Ikegami Lab was a small community, tightly knitted together, not simply by professional competences and commitments, but first and foremost by close personal and emotional ties. Ikegami himself, had, after all, carefully hand-picked this small group of people upon their personal and ideological qualities. They were, in other words, a tightly-knit group of researchers, who had been hand-picked by Ikegami and who now followed him in realizing his long-standing dream to "construct artificial life in the real world". And as such, the collectively felt like pioneers and, as one lab member said, like "misunderstood geniuses", who were on a mission to radically change the world of science and the course of the world itself, just like Albert Einstein, Richard Feynman,

or the Wright Brothers had done before them¹¹. They are, to put it simply, zealots of Ikegamianism.

Methodology

During fieldwork, I incorporated four techniques: 1) intensive periods of participant observation at the Ikegami Lab, 2) brief and targeted visits to institutions collaborating with the Ikegami Lab (for example, to ELSI at the Tokyo Institute of Technology), 3) long-format semi-structured interviews with both current and former members of the Ikegami Lab, and 4) ongoing surveys of peer-reviewed and popular science accounts particularly related to the Ikegami Lab and generally related to the field of artificial life. Needless to say, ethnographic fieldwork is an eclectic undertaking, and my activities in the field included, but were not limited to: chatting, conversing, interviewing, drinking beers, holding stuff, taking notes, taking photos, filming, smoking cigarettes, eating breakfast, eating lunch, eating dinner, and so on.

When I commenced my fieldwork, Ikegami had kindly offered me a desk in the lab and I was given access to the university Wi-Fi. I was usually stationed here about 2 to 4 days a week, but in any given week, however, only about 3 or 4 lab members would be in the lab simultaneously, working on their own individual research project in front of their laptops. Whenever lab members were in, they would typically come in at noon or late in the afternoon, take off their shoes at the Genkan (the traditional Japanese entryway area), open their laptops, and plug in their headphones. Subsequently, they would sit for the next 4 to 6 hours tapping on their keyboards, listening to a playlist or a podcast, before going out to get dinner somewhere in Tokyo. It was usually the same lab members, who frequented the lab, while the rest of them were working from home, at some café, or at the university library. To illustrate their working routine, one lab member told me, “as long as I have my computer, I can work anywhere [...] I sometimes work at the library, in coffee shops, or simply at home.” And when I asked a lab member about her work routine, she replied, “I don’t

¹¹ This feeling of determination and purposefulness was very pronounced among the lab members, who not only spoke highly of Ikegami, but also often idolized people like Einstein, Feynman or the Wright Brothers during our many conversations, which will also become apparent later on in this thesis. Perhaps it is no coincidence that many of them saw in Ikegami a leading star, whose personal qualities and intellectual prowess had the potential to radically change the world?

really have routine. I'm always working on different things, there are always different events to attend to, and both my lab and my part time job have free hours. Not two days are the same, so I work as soon as I get some free time.”¹² Thus, while I was usually at my desk in the lab, I would occasionally have to walk down to the library to see if any lab members were in. But when a lab member was in, I would carefully make sure I did not disturb or interrupt their work, and approach them in a casual way. Whenever they had “free time”, for example, when they would go out to get dinner in the evening, I would usually arrange an interview in order to make sure I would be able to ask them about their work in a more structured and formal fashion.

However, when I was not at my desk, I attended as many activities as I could, such as attending bi-weekly lab meetings and other group meetings, participate in experiments and public events, for example, when they conducted experiments on the android *Alter*, which will feature later on, or when Ikegami was invited to do lectures or talks at different locations around the city of Tokyo. Other lab members would also occasionally do public talks at different bars and venues around the city, for example events such as Lonely Planet’s “top choice for cultural events in Tokyo”, “Nerd Nite Tokyo, bringing geeks and drinks together in the Kanto region since June 2016”. These events were less about research and more about introducing the general public to the field of artificial life. Besides attending such events around Tokyo, I was also lucky to get invited to participate in one of their main research projects on the android named *Alter* – an “autonomous” robot stationed at The National Museum of Emerging Science and Innovation, colloquially known as the “future museum”, located on the artificial island of Odaiba in one of Tokyo’s central districts. Here, I would do much of my participant-observation, following how the lab members conducted their experiments hands-on and up-close.

Now, the fact that the lab members had different and sporadic working routines, sometimes working in the lab, sometimes working from home or from some café, I was forced to stay in touch with them via social media, email and text messaging. As such, I was able to follow them around, make appointments, arrange small meetings,

¹² Many of the lab members had part time jobs at tech-companies or start-ups on the side to support themselves financially. Holding part time jobs, obviously, took a lot of their time, which was also one reason for why some of them preferred working close to their jobs or at home after a long day at work.

and generally stay updated on their whereabouts. However, not all of the lab members were equally good at replying to my text messages and requests, especially Ikegami, who always seemed very busy¹³. This, in turn, compromised my chances of following them around and made it difficult to stay in touch, and often, I had to go see them on very short notice. Sensing the shortcomings of this strategy, I nevertheless decided to set up my “base of operations” at the lab itself, seeing this as a hub, where the lab members would show up from time to time. Staying at campus provided the best chances for tracking their activities both in terms of their individual research (there were almost always at least one lab member in) and in terms of keeping myself updated on any upcoming events, for example, such as lab meetings, gatherings, symposia, talks, lectures, and so on. My most valuable data, however, was collected on the basis of doing interviews at the lab, at bars and venues around Tokyo, and of doing participant-observation at public events and experiments.

Interviews

In between passing time at the lab, I frequently found openings to arrange and perform semi-structured interviews. Many of the lab members, except Ikegami, seemed little accustomed to being questioned in a formal interview-styled manner, but they always seemed to enjoy sharing insights of their work. Most of the lab members, while being unaccustomed to being interviewed (usually, Ikegami was the one who would take inquiries) agreed to do interviews. However, a few of them felt less comfortable doing interviews, perhaps because they felt uncomfortable expressing themselves in English. When approaching them, I tried to the best of my ability to be sensitive to how they felt about the situation and had to give up some interviews in order not to seem pushy. Thus, I never managed to interview all the lab members, but had to rely on a few of them. Needless to say, this affected the sort of data I was able to generate by narrowing the range of perspectives I was able to get.

Now, notably, in relation to my interviews, some of the lab members politely advised me to do my “homework”, noting that they would, “rather that we’d discuss something interesting and not just the usual basic stuff”, and so advised me to come

¹³ I made several appointments with Ikegami during fieldwork, many of which were cancelled due to his inability to reply to my texts or because he had been otherwise prevented.

prepared. Coming prepared, for example, meant that I would read up on some of the basic concepts and theories in advance so I could heighten my chances of understanding what they were actually talking about. However, whether prepared or not, they tolerated my ignorance of artificial life and its universe of intricate concepts and readily replied to all my questions¹⁴.

During interviews, I rarely asked questions about their private life unless they went there themselves. Instead, I concentrated my questions directly on their roles as professionals. I asked questions, for example, about their individual research projects; about their ways of working; about their relationship to other lab members; about certain relevant and irrelevant theories and concepts; about other fields and scientists, and about how they envisioned the future of artificial life. Often, I would use interviews to support the observations I had made at the lab, for example by asking them during an interview to guide me through one or more of their self-made simulations I had seen them working on during the day. This meant that I would sometimes use interviews to engage with their work in more detail by interviewing them in a tighter format, a closed format by which I was able to instruct them to walk me through their work. Doing so, I combined my interview with a sort of “point-and-click”-tour of their models, while they were happily naming their “artificial organisms” and telling me about these fantastic “digital worlds”. This, in turn, also revealed what inspired them and how they thought about their work and their models.

In total, I conducted 25 formal semi-structured interviews¹⁵ with 10 different people, which lasted between one and two hours each. All my interviews were conducted on protocols based on both closed and open-ended questions, which I formulated in

¹⁴ I would like to add here that many of the lab members were also happily surprised that someone outside the field of artificial life, artificial intelligence, machine learning and computer science had taken interest in their individual projects. However, some of them remained suspicious about my intentions and what I hoped to achieve, sometimes confusing my work as a researcher with that of a journalist writing a popular science article about artificial life as a “cutting-edge” pioneering science. Of course, this suspicion was in part motivated by my own questions about how they envisioned the future of their field. Also, I often had the impression that some of them felt somewhat uneasy about the interview-format in terms of its methodological efficiency, but this is not to say that they were feeling uneasy during the interviews. Interviews, in other words, were not part of the artificial life methodological toolbox, which also exposed our professional differences.

¹⁵ These interviews are recorded interviews, which are supported by unrecorded conversations. I did about 10 to 15 smaller “interviews” with people outside the lab – artists, entrepreneurs, scientists, anthropologists, philosophers, etc. – which were not recorded, however, still part of my empirical material.

advance, but adjusted both during and after interviews to allow for improvisational and spontaneous turns in our conversations. Thus, depending on whether I conducted an interview with a graduate student, a PhD, a postdoc, or with professor Ikegami, I tailored my questions to fit with their respective positions. For example, in the case of Ikegami, I aimed for an unstructured and loose format by asking a range of open-ended questions in order to make him offer, say, a general overview of the field of artificial life. By this strategy, I wanted to allow Ikegami to steer the course of our conversation and thereby allow him to define the content to better identify what he believed to be at stake and what he saw as the primary concerns in relation to his work as an artificial life researcher. For example, seeing Ikegami as a main interlocutor, I would initially ask him very basic, open-ended questions, such as, “what is artificial life and how would you, in your own words, describe the field?”; “please describe a typical day at the lab?”; “what sort of research projects are you doing here and what are they about?”, and “how do you see the future of artificial life?”, and so on. Such questions gave me with a general sense of the lab and thus helped me establish a foundational understanding what was at stake at the lab. Along the way, I would tighten the format a bit and tailor follow-up interviews accordingly, so I would pick up on the information I had been given and slowly begin to relate and connect themes and topics to form a sort of “map of concerns” inherent to the lab¹⁶.

Now, consequentially, one of the limitations in keeping a loose format (that is, by initially allowing Ikegami to control the content of our conversation), I came to notice, was that our conversations turned too abstract and incoherent. Ikegami often wanted to discuss “big thoughts” and thereby often steered our conversations into deep theoretical, speculative, and philosophical waters. That is, Ikegami and I, unlike my conversations with lab members, would often engage in huge philosophical debates or theoretical tugs-of-war, for example, on topics such as Cartesian divides, posthumanism, postmodernism, Gilles Deleuze, Shusaku Arakawa, or anti-structuralism. Moreover, this was sometimes peppered with discussions about art, music, literature, Osaumu Dazai, Kenji Miyazawa, nature, non-human perspectives and where to buy good coffee. Yet, it was exactly in such moments I began to realize

¹⁶ It was by mapping a “network of concepts”, so to speak, that I became acquainted with Ikegami’s self-invented concept of “massive data flows” (MDF, which I will touch upon later), and by which I was able to query his world of ideas. I will come back to this concept later on in this thesis.

that Ikegami was in command of a rich philosophical vocabulary, but this also revealed that he casted himself as an avant-gardist and a sort of “philosopher king” at the lab. And this, I later reckoned, resonated soundly with his self-image as an artist-scientist and his vision of artificial life. Indeed, well-versed in the philosophical underpinnings and the artistic potentials of his field, Ikegami was assiduously constructing artificial life as a sort of intellectual vanguard and himself as a forward-looking Renaissance-man. In retrospect, his competence and eloquence in, say, postmodernist vocabularies might sometimes have had a mesmerizing effect (or perhaps a paralyzing effect?) on our conversations. However, in any case, his larger-than-life-Renaissance-man-attitude vividly exposed his desire to exhibit intellectual prowess and foresight.

On a general level, whenever possible, I recorded the interviews and later transcribed them, either fully or partially. If an interviewee preferred not to be recorded, I would take notes during or after the interview, usually by hand to include them into my field notes. All my interviews were conducted in person, and whenever possible, they were held privately, even when interviewees preferred meeting in a public venue, such as a café. All interviews, finally, were conducted in English, in which most of the interviewees were either proficient or native speakers. Of the 25 interviews, about half of them were with Ikegami himself, whenever he had time in his busy schedule, the rest were conducted with lab members and collaborators.

Participant Observation

While interviews, informal conversations and chats with Ikegami and lab members comprise a good portion of my empirical material, I also recorded about 500 pages of field notes based on participant observation. These pages include sober and dispassionate field observations, personal reflections, diary-like notes, frustrations, angry outbursts, and memos-to-self. The bulk of participant observation have been done at The National Museum of Emerging Science and Innovation, colloquially known as the “Miraikan”, or literally the “future museum”, and during events around Tokyo, for example, such as Nerd Nite. While I did participant observation at the lab in the sense that I was talking to, and looking over the shoulders of, the lab members,

as I tried absorb the general feel of the place, I sometimes joined some of the lab members when they did collective experiments.

At the time of my visit, a few lab members – Doi and Atsushi - were particularly engaged in a joint research project on the android named *Alter*. *Alter* is one of the most prominent examples of one of their many creations at the lab, an upper-body robot designed, built and assembled in collaboration with the Intelligent Robotics Lab (IRL) at Osaka University. However, while *Alter* is the result of a joint research collaboration, it was at the time when I did my fieldwork stationed at the Miraikan, and a few lab members from the Ikegami Lab had taken the responsibility to carry on new experiments on it. Whenever possible, I would join them at the Miraikan, where they had borrowed a spacious exhibition hall for conducting their experiments. However, these experiments, while visually appealing seeing *Alter* turned on and off like a wind-up toy, felt much like the sort individual experiments each lab member were engaged in back at the lab. That is, much of the work was still done on computers, writing code, adjusting values. Yet, contrary to much of the simulation work done at the lab, this sort of computational fidgeting materialized in the body of *Alter*, making its arms, torso and head move spasmodically. In other words, tracking what to me was intangible and intricate code materialize in physical movement exposed a more practical side of their work, which in turn added a new dimension that required me to do participant observation.

However, I did more observation than participation, but this is not to say that I did not participate at all. For example, while Ikegami was not usually present at during experiments, he would sometimes show up to keep track of the progress and to discuss new ideas, further developments or initiatives in relation to *Alter*¹⁷. In these moments, Ikegami often included me into such discussions, but he also sometimes used me as a sort of test subject, asking me to assess, evaluate and communicate my experience of *Alter*. At one point, for example, he asked me to rate *Alter*'s "presence" on a scale from, "very human-like" to, "very robot-like" with reference to Masahiro Mori's concept of the "uncanny valley" – a hypothesized relationship between the degree of an object's resemblance to a human being and the emotional response to

¹⁷ Later in this thesis, I will account for such experiments in more detail.

such an object. Being included in such experiments, needless to say, also made me feel included their work, particularly the “Alter project”, and my role as a test subject (while perhaps not always desirable) made me feel like a valuable part of the process to refine and attune the “feel” of Alter. To this end, while my ineptitude in the language of programming barred me from close to the internal logics of their work as such, my aptitude as a test subject and critic made me a useful asset to their work.

Sequence Map

Chapter 2, *The Evolution of Artificial Life*, is an introductory chapter taking a tour through the history of artificial life, or what Ikegami calls the “evolution of artificial life”. In this chapter, I unpack the historical “evolution” of artificial life, seen from the perspective of the lab members, seeking to reveal how they arrived at the conviction that “life” is better “understood” by its “construction”. As we shall see here, their enterprise is not ahistorical, nor uncultured, but rather enabled by a slew of social, scientific, intellectual, technical, and historical possibilities. The so-called evolution of artificial life, as narrated by the lab members, is thus segmented into three distinct, although overlapping, “eras”, or “evolutionary stages”, beginning with the “computer era”, mutating into “chemical era”, which thread their way into the “third” and the current era, which is marked by the lab members’ self-described mission to “construct artificial life in the real world”. The purpose of this first introductory chapter, in short, is to provide a clearer sense of the social, cultural and historical contexts in which these researchers at the Ikegami Lab are embedded.

Chapter 3, *Maker’s Knowledge*, takes us from the history of artificial life into the lab itself to take a closer look at what the lab members mean by “construction”. “Construction”, they say, is as a way, in fact the only viable way, to better “understand” what life is, and so, in this chapter, I reveal that their approach to better understand what life is, and what it can become, is essentially underwritten by a constructive approach to vitality. Using a few examples of models constructed at the lab, I show how the lab members basically treat “life”, including the theories and concepts they associate with it, as conceptual categories that may be explored and

understood via their *de novo* construction in the lab. That is, constructing computer models, for example, is a way to explore *and* materialize what they understand, and seek to understand, about life and the living. Along the way, then, I thereby demonstrate how construction either precedes or is simultaneous with understanding, a confluence I call *makers' knowledge*. The main purpose here is to unpack the lab members' construe the relationship between “construction” and “understanding” in order for me to establish the basis for what I mean by parallax machines.

Chapter 4, *The Word for World is Massive Data Flows*, however, is not about parallax machines, but takes us from maker's knowledge – i.e. how the lab members construe the relationship between “construction” and “understanding” – to the question of what they mean by the “real world”. Namely, in this chapter, I show how Ikegami “performs” an ontology, indeed how he articulates the principles of reality, by which the lab members are invited to see the world. The “real world”, according to Ikegami, is a media-specific reality of data and information, swirling in space-time, flooded by what he calls “massive data flows”. The real world, then, is at once erratic, stochastic, unpredictable, and is therefore also ontologically *out of sync* with the sort of digital worlds conjured in chapter 3. This ontology, finally, is one of the central components to ontoepistemological framework I call Ikegamianism.

Chapter 5, *Attuning to the Emergent*, constitutes the second central component of the ontoepistemological framework I call Ikegamianism. Here, I continue my discussion from chapter 4 to explore in more detail how Ikegami pushes for a paradigm shift in science. That is, in order to attune to and apprehend “massive data flows”, as we saw in chapter 4, Ikegami also seeks to outline the contours of what he calls a “new epistemology of artificial life” – a new critical framework with which to apprehend, and potentially create new meanings of life. This new epistemology, I show, is another central part of Ikegamianism. This epistemology relies not on strict scientific formalism, but rather on the presence of what Ikegami calls an “internal observer”, who, as the subtitle of this chapter suggests, must learn how to “attune to the emergent by cultivating a certain kind of embodied, phenomenological sensitivity to the yet-to-come, to surprising events, to the emergent. Thus, this epistemology, I want to assert in this chapter is not only inextricably tied to the ontology of MDF identified

in chapter 4, but it is also a central part of Ikegamianism. What life is, its form and meaning, according to Ikegamianism, must be based on the aesthetic judgement of the internal observer not on rational judgement.

Chapter 6, *Parallax Machines*, is the culmination of chapter 4 and 5, centering on how Ikegamianism is put to work in practice and in discourse. To illustrate how Ikegamianism materializes in what I call *parallax machines*, I unpack a specific cultural event: the anthropoid opera *Scary Beauty* - the world's first "android opera" featuring *Alter*, an upper-body android, which is the first "real-world" android to "autonomously" conduct a human orchestra. In this final chapter, then, I explore how artificial life is by Ikegami considered "larger" than biological life through examining the anthropoid *Scary Beauty*, seeing in this an instance of "collaborative sensing practices". As such, *Scary Beauty* may be seen as a collaborative human-machine sensing practice, by which *Alter* comes to function as a parallax machine, embodying Ikegamianism *and* inviting the audience of *Scary Beauty* to adopt what I claim is a *parallax view of life* - a view which is made possible exactly because *Alter* is deliberately constructed to be real and unreal, indeterminate and incomplete. Yet, while this is so, I stress that Ikegamianism is simultaneously built *into* *Alter*, and as such *Alter* becomes a materialization of Ikegamianism, while also reflecting a parallax view of life by synthesizing two seemingly incompatible notions of life, one artificial, one biological, without fully resolving them. As such, parallax machines, I argue, are both embodiments, materializations and prisms of Ikegamianism by which "life" can only be grasped by a kind of parallax view.

2

THE EVOLUTION OF ARTIFICIAL LIFE



A silhouette of professor Takashi Ikegami in his office at Komaba Campus, University of Tokyo. Photo courtesy of: author.

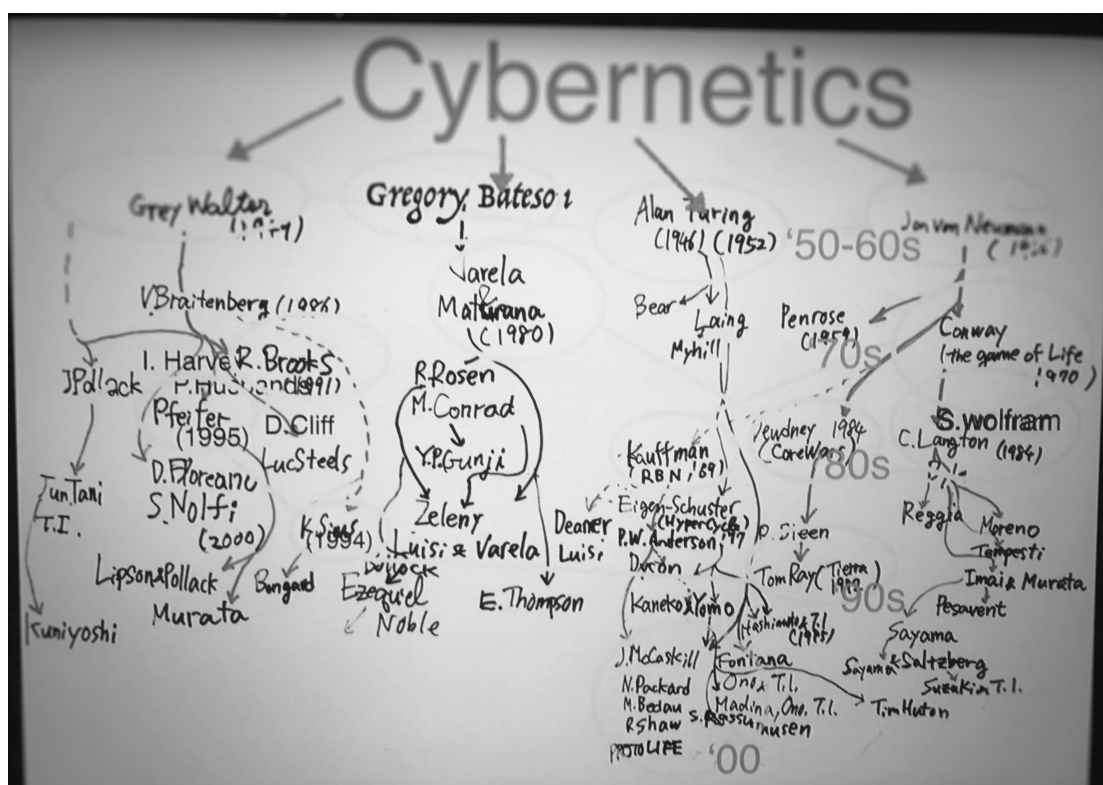
Introduction: The Evolution of Artificial Life

In a dimly lit conference room at the 7th ELSI International Symposium Public Lectures at the Tokyo Institute of Technology (Tokodai), held in November 2018, Ikegami opens his lecture with a diagram titled the, “evolution of artificial life”. On a timeline spanning from the 1950s to the 2000s, aligned vertically from the top-down, forking and curving lines of descent cut down from four seminal “roots”. The diagram, subtitled, “four seminal paths to create life”, Ikegami tells the audience, is supposed to visually track, in taxonomic fashion, the intellectual lineages of artificial life. The “roots” at the top refer to the four “founding fathers”: Grey Walter, Gregory Bateson, Alan Turing, and John von Neumann¹⁸, each of which have, in their own way, highlighted what Ikegami sees as some essential feature or property of life and the living. At a glance, the viewer is presented to a diagrammatic branching structure that supposedly maps common ancestry of related figures. Bateson’s lineage, for example, draws lines of descent down to Francisco Varela and Humberto Maturana, to Michael Conrad and Evan Thompson, while von Neumann’s lineage cuts down to John Conway and Christopher Langton. Shorter branches identify more evolutionarily recent convergences, while some stippled horizontal branches display “lateral transfers” between the lineages. A couple of months prior to this event, I encountered the exact same diagram at another symposium. Ikegami, I discovered during fieldwork, often used this diagram to explain to “outsiders” the intellectual roots of artificial life, emphasizing that he and his team of researchers were not only working in continuation of the four “founding fathers” but they were also on a mission to “merge” them.

Notably, Ikegami’s diagram displays lineages of intellectual relatedness, even descent, between the “founding fathers” and artificial life’s own path to “create life”. As such, it becomes a sort of phylogenetic “model” of the field’s past, threading its way into the present. His four-fold, and to me rather intricate, diagram neatly follows the logic of taxonomy as if Ikegami was somehow trying to “evolutionize” the history

¹⁸ Grey Walter (1910-1977), a neurophysiologist, cybernetician and robotician, Gregory Bateson (1904-1980), an anthropologist, semiotician and linguist, Alan Turing (1912-1954), a mathematician and computer scientist, and finally John von Neumann (1903-1957), also a mathematician and computer scientist.

of artificial life by mapping ancestry in a phylogenetic idiom in a somewhat Linnaean fashion¹⁹. Yet, what is “transferred” along these evolutionary lineages is not genes, but rather ideas, concepts and possibilities that are meant to reveal artificial life’s common ancestry to be somewhat predetermined and codified into a system of intellectual genealogy. Still, the lineages do not converge, but rather pan out along separate lines of descent, leaving space open for further evolutionary developments, ending somewhere on the vertical timeline around 2000. The fact that these lineages do not merge or resolve into one another, however, is not a mistake. Rather, I learned, it is a deliberate trick to suggest that artificial life’s evolutionary “development” is still an ongoing process, and the task at hand for Ikegami and his team of researchers is to consolidate all the previous attempts to “create life”.



When Ikegami explained his diagram to me during fieldwork, he told me that artificial life had entered its “third era” – the most recent era and the contemporary outgrowth of a longer genealogy of the field. Following along, then, this chapter takes its outset from Ikegami’s diagram, and its accompanying discourse, to explore what

¹⁹ The Swedish naturalist Carl Linnaeus, sometimes noted to be the “father of taxonomy”, was the one who differentiated Plantae and Animalia in 1735, like Ernst Haeckel, who later, in 1866, added Protista to Linnaeus’ diagram.

Ikegami means by this “third era”. Thus, in this chapter, I deliberately use Ikegami’s diagram as a launching pad for unpacking the history of artificial life in order to frame how the lab members at the Ikegami Lab are embedded in a longer history of social, scientific, intellectual, technical, and historical possibilities. Ikegami’s diagram, then, is not only a visual device with which to sketch the genealogy of artificial life, but here also an outset to explore, in the words of Ikegami, the “evolution of artificial life”.

If Ikegami’s diagram materializes the evolutionary development of a cultural history of people and ideas, it does so by explicitly using tropes otherwise found in taxonomic practices, such as evolutionary taxonomy, to classify organisms by shared and serial descent and degrees of evolutionary change. As such, I want to follow this logic to unpack this evolution of artificial life, using Ikegami’s diagram as a sort of cursor through which to tell the history of artificial life as going through a series of changes. Yet, while the diagram does not explicitly show these changes, it nonetheless contributes here to provide an overview of how Ikegami arrived at the conclusion that one needs to “construct artificial life in the real world”, a conviction, the diagram reveals, which is paved with a slew social, scientific, intellectual, technical, and historical possibilities.

In what follows, then, I want to do two things: first, following Ikegami’s own narrative, exemplified in his diagram, I want to sketch what constitutes the “first” and “second” “eras” in order to establish a backdrop on which to better understand what Ikegami means by the “third era”, the era in which they seek to construct artificial life in the real world. What I want to argue is that imagining the evolution of artificial life in evolutionary terms streamlines the history of artificial life into an unbroken continuity between past, present and future (cf. Ssorin-Chaikov 2017). Ikegami’s diagram, and its associated discourse, then, is hereby not only exemplary of how the lab members ground their claims for the field in a venerable intellectual lineage, but also in a *genealogy*, even an explicitly *evolutionary* one leading up to the third era. Along the way, as I pace through the first, second and third era, I will lay out some of essential milestones in the history of artificial life, which are also inherent to the enterprise at large. So, while unpacking this narrative, I want to take this opportunity

to offer a broader overview of some of the rhetorical, technical and scientific imports that have been brought into the Ikegami Lab, imports that underlie much of the current work, which I will explore in the following chapters.

Thus, the purpose of this first introductory chapter is two-fold: first, to show how they situate their enterprise in an explicitly *evolutionary* trajectory by which they imagine themselves and their work as the outgrowth of this evolution and from where they further seek to articulate their own “merged” version of artificial life. Second, I hope this will provide a clearer sense of what is at stake among the researchers at the Ikegami, who believe that the only way to truly understand what life is and how it works is by constructing it in the real world. Now, before unpacking the evolution of artificial life, allow me to begin by outlining, from the “bottom-up”, a brief overview of the artificial life’s beginnings.

In the Beginning, From the Bottom-Up

The just-so story of artificial life goes, according to the field’s founder, Christopher Langton (1989) - a computer scientist holding an undergraduate degree in anthropology from the University of Arizona – that the field is a hybrid of computer science, theoretical biology and digital gaming devoted to mimicking the logic of biology in the virtual worlds of computer simulation and in the hardware realm of robotics (Langton 1989; Helmreich 2016). Officially emerging in the late 1980s, specifically in 1987, the field was drawn into coherence, by most canonical accounts, by Langton himself following a workshop at the Los Alamos National Laboratory, New Mexico, US. In subsequent years, during the 1990s, interest in the field grew steadily, attracting scientists of all stripes - from computer science, engineering, mathematics, physics, psychology, anthropology, linguistics, etc. – who clustered at the Santa Fe Institute (SFI), an institute dedicated to the multidisciplinary study of the fundamental principles underlying complex adaptive systems, including physical, computational, biological and social systems.

This new breed of researchers, naming themselves in analogy to artificial intelligence (AI) as “artificial life researchers”, or “Alifers”, began organizing workshops, which in turn transformed into an ongoing international series. And with the proliferation of artificial life, the practitioners in the field have at least since the late 1980s been organizing dozens of international conferences, culminating in 1993 when they made their first journal publication dedicated to the work of mimicking the logic of biology in the virtual worlds of computer simulation and in the hardware realm of robotics. To this day, the small handful of scientists, who originally congregated at the SFI, have slowly grown into a small international community with researchers from all over the world, based in countries such as the United States, Japan, United Kingdom, Denmark, Germany, France, Belgium etc.

Most prominently, as it began back in the late 1980s, what united this niche community of researchers were collective efforts to somehow “simulate” or “synthesize”²⁰ the logic of biology in computational media in an attempt to expand biology’s purview to include not just “life-as-we-know-it” but also “life-as-it-could-be” – life is might exist in other materials or elsewhere in the universe (cf. Langton 1989; Helmreich 2016:4). Artificial life, then, was not built on a curiosity to discern the workings of “living organisms” by studying them directly, like biologists usually do, but rather, as Langton further assumed, to get at “the dynamic processes that constitute life – in whatever material bases they might occur”, upon the belief that life, “must share certain universal features – features that will allow us to recognize life by its *dynamic form alone, without reference to its matter*” (Langton 1989:1 my emphasis). Thus, as Langton further noted, “life” is no special substance, but rather, as he claimed, “a property of the *organization* of matter, rather than a property of matter itself” (Langton 1989:2 my emphasis), a position that offered, anthropologist Stefan Helmreich (2016) notes, an extreme Platonism, by which life’s form could be completely pried apart from its matter (Helmreich 2016:6). This Platonism, in turn, has since become the implicit hallmark of artificial life’s epistemological scaffolding: that “life” is less likely, many artificial life researchers claimed, and still claim, a

²⁰ The designations “simulation” and “synthesis” have been circulating in epistemological debates among artificial life researchers since its beginning, debates revolving around the relation between the world and the agent that knows. Such debates have often been encapsulated in the vacillation between “strong” and “weak” claims in artificial life, between the idea that artificial life practice “simulates” or actually “synthesizes” vitality (cf. Helmreich 2016)

property of its matter, but rather the “organization” of matter itself. As we shall also see later, this view is shared by the lab members at the Ikegami Lab too.

Now, such efforts may immediately resound Promethean aspirations to create “life” in non-organic substrates. And indeed, there are countless of attempts to do so, which may be said to precede the field of artificial life itself, for example, as some technological experiments in medieval, Renaissance, and Early Modern automata may to some degree constitute early examples of “artificial life”. Early attempts to make novel life forms, for example, as historian of science Jessica Riskin (2003) notes, may be located among figures such as the eighteenth-century French watchmaker, Pierre Jaquet-Droz and his sons, who used, “lifelike materials such as leather, cork, and papier-mâché to give their machines the softness, lightness, and pliancy of living things.” (Riskin 2003:606). Similarly, one may equally locate efforts to make new life forms in many literary sources that highlight some of the consequences of such Promethean aspirations, for example in stories such as Rabbi Löw’s Golem – an assortment of stories about how the golem was brought to life and afterwards controlled – Mary Shelley’s *Frankenstein; or, the Modern Prometheus* - famously featuring a jigsaw creature jolted to life with electricity – or the homunculi of the medieval alchemist Paracelsus – a story that have given rise to imaginative speculations on the quest for artificial life. Such efforts, in a Japanese context, may also be traced back to Makoto Nishimura’s “Gakutensoku”, allegedly Japan’s first robot built in Osaka in 1928. The name of Nishimura’s newly built robot, made as a tribute to Emperor Hirohito’s ascension to the Chrysanthemum Throne, means “learning from the laws of nature”, a machine capable of changing its facial expressions via springs and gears in its head, puffing its cheeks as if breathing, through pneumatically inflatable rubber tubes.

However, while there are plenty of sources that center on humanity’s purported cravings to create new life forms, in turn arousing equal measures of skepticism and fascination (cf. Whitelaw 2004:2), the field of artificial life may not necessarily be directly linked to such stories, wherever one may find it. As anthropologist Stefan Helmreich (2016) reminds us, “a search for ancestors carries acute historiographical and epistemological dangers,” (Helmreich 2016:36), so that if one simply claims that

the notion of synthesizing life can be traced back to stories, such as the Jacquet-Droz family, Mary Shelley's "Frankenstein", or Nishimura's "Gakutensoku", one may overlook quite recent origins of the very idea of a field of "biology" as such, a field that has "life" as its animating object (Helmreich 2016:36). Instead, as Helmreich notes, artificial life has *many* histories, "not all of which are about vitality, or even machines" (Helmreich 2016:37). At the Ikegami Lab, though, many of the lab members follow the official canon of artificial life.

So, to go back to the just-so story of artificial life, artificial life is basically animated by positing that "life" is fully materialistic, involving no "soul" or "vital force", for example, as akin to what philosopher Henri Bergson (1911) called "elán vital"²¹ (Bergson 1911). Rather, as Langton claimed, "living organisms are nothing more than complex biochemical machines" (Langton 1989:2). Ideas such as these have in large parts been inspired by theoretical biologists of different stripes, who, in the 1970s, 1980s, and 1990s, struggled to offer universal accounts of life and living systems. In 1974, for example, biologists Francisco Varela and Humberto Maturana (1974) offered the theory of "autopoiesis", which posed that organismic integrity and form could be understood in and through the dynamics of self-organization (Varela et. al. 1974). Biological life and living organisms, what they called "living systems", were self-organizing, biochemical machines that dynamically reproduce and sustain their internal regulation and boundaries to the external world (Varela et. al. 1974). In other words, they offered an account – and a hugely popular one – based most prominently on living systems as self-organized form.

²¹ Elán vital is a term coined by philosopher Henri Bergson in his book *Creative Evolution* from 1911, in which he addresses the question of self-organization and spontaneous morphogenesis of things. While such issues are also highly pertinent to artificial life researchers, who also concern themselves with questions about self-organization and morphogenesis, elán vital is a hypothetical explanation for how evolution and the development of organisms are closely linked to consciousness, which Bergson defines as the intuitive perception of experience and the flow of inner time (Bergson 1911).

Others, for example, such as the biologist Brian Goodwin (1994), in his book *How the Leopard Changed Its Spots*, attempted to tackle similar questions about life's form asking, "why life is capable of such diversity and beauty of forms while at the same time revealing an underlying unity" (Goodwin 1994:31-32). To this question, Goodwin answered that, "organisms can take any form, have any color, and eat any food, subject only to very broad constraints that are basically due to physical and chemical laws" (Goodwin 1994:87). Goodwin thus maintained, analogous to Varela and Maturana, that living systems, or living form, are basically entities that are continuously engaged in the process of generating forms and transforming them by means of their particular qualities of action and agency in time and space (cf. Goodwin 1994; Varela et. al. 1974).

However, what Langton meant by the idea that living organisms were nothing more than complex biochemical machines, following theorists such as Maturana, Varela and Goodwin, to name only a few, was that "life" was not simply a formal complex structure, but rather a dynamic structure, active in time and space. For the artificial life researchers during the 1980s and the 1990s, then, the "universal features" of life were to be found in its abstract dynamic processes as occurring in *any* "material bases", in turn offering fidelity to the idea that "life" is that which cuts across any given material substrate, biological, computational, artificial. But this also came to mean for many artificial life researchers that "life" would most strongly manifest in "behaviors", "actions", and "performances" (cf. Helmreich 2016), rather than in static material objects. In turn, this gave way for the possibility for creating such dynamic structures, often involving flexible, dynamic, and tightly controllable artificial mediums, in the virtual domains of computational media. That is, in the simplest of terms, that the structures and patterns of life, as dynamically active in time and space, came to be replicable and reproducible in software, in silico (Helmreich 1998).

In this sense, living things, according to the claims made by artificial life researchers at the time, were thought of as complex dynamic systems that in turn came to inform the methodologies of artificial life. The field's focus on the "simulation" or "synthesis" of such dynamic systems, in part, lead them to adopt a so-called "bottom-up" approach, an approach that assumes that higher-order entities, ranging from

molecules to biospheres, arise from, and are the results of, the dynamic interactions of lower-order entities (Lansing 2002; Lansing 2003). For example, if a human being is considered to be complex dynamic system, it may well be higher-order entity, as the aggregate sum of its parts, with its body the culmination of molecules and tissues. The bottom-up approach, then, is thereby strongly aligned to theories often formulated and found in fields such as complex systems science, a kind of science that regards the complex dynamics of living things, including nonliving things, across *all* scales and sizes, as phenomena that basically arise from the interaction of multitudes of smaller components (cf. Johnston 2008). Complex systems science, slipping into the domain of artificial life, is readily apparent, for example, when Langton asserts that, “natural life emerges out of the organized interactions of a greater number of nonliving molecules, with no global controller responsible for the behavior of every part” (Langton 1989:2). Now, allow me to briefly take a detour through artificial life’s strong alignments to the sciences of complexity, to better pin down the epistemological scaffolding of the field itself.

Complex Dynamic Systems

Anthropologist Stephen J. Lansing (2003), who has written extensively on complex systems, notes that, “the study of complex adaptive systems, a subset of nonlinear dynamical systems, has recently become a major focus of interdisciplinary research in the social and natural sciences” (Lansing 2003:183). Artificial life is no exception, as a field whose basic approach in thinking about living systems, as Lansing further points out, is strongly aligned to complex systems science (Lansing 2002). Furthermore, Lansing adds, the nonlinear thinking of complex systems science has not only slipped into the field of artificial life, but also begun to slip into other fields, for example, such as economy or neuroscience. Concomitantly with artificial life researchers starting to think about living systems as complex dynamic systems, i.e. as higher-order composites of low-level interactions, Lansing also describes how researchers in other fields, who have become inspired by the theories of complex systems science, have begun to realize that economies, for example, like ecosystems, operate largely according to the same principles. Thus, as Lansing sees, complex

systems scientists may well assert that ecosystems and economies function analogous to, say, biological ecosystems in the way they “evolve” according to nonlinear principles (Lansing 2002; Lansing 2003).

Such kind of thinking provides ways to draw parallels and fresh analogies between domains otherwise thought to function according to incommensurable logics and/or principles. For example, the theoretical biologist Stuart Kauffman (1995), who has also been attracted to the work of artificial life, has drawn an explicit parallel between biological and economic systems, writing that, “the modern corporation is a collectively self-sustaining structure of roles and obligations that ‘lives’ in an economic world, exchanges signals and stuffs, and survives or dies in ways at least loosely analogous to those of *E. coli* [...] Both *E. coli* and IBM coevolve in their respective worlds (Kauffman 1995:300)²². What Kauffman’s example highlights is the focus on complex dynamic systems of various types arising from the “bottom-up”, an understanding that sees the private corporation IBM, the bacteria *Escherichia coli*, and living systems, whether biological or artificial, as results of low-level interactions and dynamics. Yet, such complex dynamic systems are not reducible to their parts, nor are they, as Langton suggests, governed by a “global controller”, thus they are non-linear. In turning to this nomenclature, artificial life founded much of its reputation on a bottom-up approach that begins at the bottom, viewing an organism, for example, as a large population of simple machines, and from there works upwards, in a synthetic way, which means to construct large aggregates of simple, rule-governed objects which interact with one another non-linearly in the support of “lifelike”, global dynamics (cf. Langton 1989).

Meanwhile, though, as artificial life researchers claimed to replicate the logic of biology on artificial media, working upward from the bottom-up, many of

²² I want to add an anecdote from my fieldwork here, as many of the lab members were reading popular science books to make claims, for example, for the ways social networks on social media platforms tend to mimic the rules and functions of biological life. *The Social Organism* – a book by entrepreneurs Oliver Luckett and Michael J. Casey (2016), makes the claim that in sharing and replicating packets of information known as memes, the world’s social media users are facilitating evolutionary process just like the transfer of genetic information in living things. They argue that memes are the basic building blocks of our culture, “our social DNA”, they write (Luckett & Casey 2016). Many of the lab members were enamored by such analogies.

practitioners became enamored by the notion of “emergence”²³, a concept holding many, sometimes mutually exclusive meanings, but often meant to explain, in artificial life circles at least, the crucial leap complex dynamic systems make from nonlife to life (cf. Whitelaw 2004). As such, emergence is what happens by way of simple components interacting to produce complex “lifelike” behaviors. In turning to emergence, then, some artificial life researchers began seeing complex dynamic systems as “emergent phenomena”, which denotes phenomena capable of displaying unexpected and surprising properties that cannot easily be predicted in advance of its own unfolding. For example, in some accounts of artificial life, emergence has been said to be found in multicellular organisms (Furusawa & Kaneko 1998), in the surprising appearance of small-scale societies (Read 2003), in the formal features of complex systems theories (Kubik 2003), and even from simulation results (Ronald et. al. 1999). Still, to this day, some of the most popular examples emergence in artificial life systems can be found in John Conway’s “gliders”, in his model *Game of Life*, or the flocking behaviors of Craig Reynold’s *boid-model*, which have been said to display emergent behaviors (Johnston 2008). In short, just as artificial life researchers began to claim that the behaviors of complex dynamic systems “emerge” in surprising ways from the interactions of nonliving parts and circumstances, they simultaneously began recreating such processes in artificial media, most commonly in computational media, so that an assemblage of simple computational parts interact to spontaneously produce “lifelike” dynamic structures.

Much of this thinking, I want to make clear by now, is being recycled at the Ikegami Lab, notably apparent in their claim that, “life is an emergent phenomenon”. Yet, to further exemplify this field-founding “bottom-up” approach, as it also pertains to emergence, and the claim that “life is an emergent phenomenon”, which are central

²³ Much of artificial life’s reputation was founded on the idea of emergence, as the field’s founder Christopher Langton (1989) noted in the late 1980s, “The key concept in Artificial Life is emergent behavior”, seeing that, “natural life emerges out of the organized interactions of a great number of nonliving molecules, with no global controller responsible for the behavior of every part. Rather, every part is a behavior itself, and life is the behavior that emerges from out of all the local interactions among individual behaviors.” (Langton 1989:2-3, my emphasis). However, while the notion of emergence is appealing, at least to artificial life researchers, it is also extremely tricky, as cultural theorist Mitchell Whitelaw sees, “part of the appeal of emergence as a concept is that it defies clear definition. Its function in a-life discourse often seems to be a form of antiexplanation, a vague answer blocking off further investigation.” (Whitelaw 2004:217).

concepts to artificial life and to the Ikegami Lab itself, it might serve to show how the methodologies and approaches within the field of artificial life differentiate from, say, methodologies and approaches in the field of artificial intelligence (AI). While artificial life is named in analogy to artificial intelligence, it does not, unlike AI, promise to provide a fully formalized account of “intelligence”, but rather promises to articulate a fully formalized account of “life” (cf. Helmreich 2016). As such, artificial life, even to this day, frequently tends to define and present itself against the failures of AI. For example, as Langton explains, in focusing on “intelligence”, the underlying mechanisms of which are poorly understood, according to Langton, AI is left without a “model” to follow, thus resorting to “serial computer programming” that carries, “no demonstrable relationship to the method by which intelligence is generated in natural systems” (Langton 1989). In other words, AI, unlike artificial life, fails at pointing out its referent, as AI-systems are not, Langton contends, based on or related to any referent in the biological domain.

Moreover, a more distinctive marker of difference between the two fields is found, perhaps, by AI’s drive to make computer programs or “expert systems” that can “think” from the “top-down”, which is often conflated with the ability to solve very complex tasks. That is, if artificial life’s “bottom-up” approach deals with “behaviors” and “structures” that “emerge” from the “bottom-up”, which, as Langton claims, makes them stay “true to natural life,” following key insights that “nature is fundamentally parallel”, AI does the opposite. If natural systems are complex aggregates of parts, each of which has its own behavioral repertoire, behavior arises out of parallel operation of these parts. Or, as science studies scholar John Johnston (2008) puts it, “the real questions”, for artificial life researchers, “are how global properties and behaviors *emerge* in a system from the interactions of computational ‘primitives’ that behave according to simple rules and how these systems are enchain in dynamic hierarchies that allow complexity to build on complexity.” (Johnston 2008:13 my emphasis). In contrast, then, the top-down approach pursued by AI, following the logics of artificial life, does not allow complexity to be built from simplicity, nor does it allow complexity to build upon complexity; AI, in other words, tries to make complexity simple, working from the top-down.

Now, much of this sort of thinking, including those formal methodologies, strategies

and techniques, I want to foreshadow here, have also slipped into how the lab members at the Ikegami Lab think and talk about their work and their object of inquiry, “life”. This should also become readily apparent throughout this thesis, but for now, however, since artificial life has many histories, to go back to Helmreich, I simply want to outline how Ikegami and the lab members tell their own history of their field, a story, in which artificial life is neatly segmented into three so-called “eras”: the computer era, the chemical era, and the current “third era.

The Computer Era

When artificial life first “emerged”, one might say, largely concomitantly with the mass-distribution of the personal computer (PC), practitioners in the field began developing, adopting and implementing a slew of formal methodologies, strategies and techniques that apply to their thinking about life and living systems as complex dynamic systems. This repertoire of tools, perhaps needless to say, is not fixed or static, as we shall also see in this thesis, but rather dynamic and changeable. But according to Ikegami, the first set of formal methodologies, strategies and techniques were developed during what he refers to is the “computer era”, an era, he says, “when artificial life began working with computer simulations”. In order to sketch what this first era entails, I here want to sketch three essential techniques that are endemic to the computer era, techniques that have been applied to simulate and/or synthesize aspects or properties of life, such as homeostasis or evolution. Central to these techniques are, of course, computational media as the era’s name also entails, as a core component for either simulating or synthesizing some feature or property of life and the living.

The first technique is known as *genetic algorithms* (GA), a central technique to simulate biological genetics on digital computation, commonly associated with computer scientist John Holland (1992), who, in 1960, based GA’s on the concept of Charles Darwin’s theory of evolution. Basically, a GA involves a “genotype” – the genetic constitution of an individual organism – which is a string of code specifying a “phenotype” – a set of observable characteristics of an individual resulting from the

interaction of its genotype with the environment. The phenotype can be any digital artifact or thing, for example such as an artificial organism, a three-dimensional form, or simply a piece of software. By simulating the genetic variations caused, say, by sexual reproduction and mutation, a GA changes the genotype and the phenotype, but since this process is computationally and algorithmically specified, rather than biological as such, breeding happens at an accelerated rate. Thus, with GA's, wide ranges of possible phenotypes can be generated, which are typically evaluated for their "fitness", based on some formal criteria. In functional applications of GA's, which are capable of accelerating processes of evolution, they are applied, for example, to find solutions to complex problems by searching within a wide range of *possible* outcomes.

For a concrete example of GA's, Holland developed *Echo* – a simulation tool to investigate mechanisms, which regulate diversity and information-processing in systems comprised of many interacting "adaptive" agents. Echo-agents, according to Holland, interact via combat, trade and mating, and in doing so, develop strategies to ensure survival in resource-limited environments. Thus, Echo basically consists of a flat spatial expanse on which a number of simple agents – "Echo-agents" – are distributed across specific sites, like pieces on a game board, with each agent possessing certain attributes defined by "tags" and "conditions" inscribed in its "chromosomes". This, in turn, enables it to interact in the ways described above: fight, trade or mate. These simple rules of interaction, Holland proposes, give rise to complex behaviors among the agents, including, ecological phenomena (e.g. mimicry and biological arms race), immune system responses (e.g. interactions conditioned on identification), evolution of metazoans (e.g. emergent hierarchical organization), and economic phenomena (e.g. trading complexes and the evolution of 'money') (Holland 1992)²⁴.

²⁴ Holland's Echo-platform has been variously described and discussed by many authors in science studies, such as Stefan Helmreich (1998) and John Johnston (2008). Helmreich, for example, shows how Holland's agent-based system, Echo, reinscribes or materializes a particular culturally specific model of the subject, namely the self-determining, competitive, "formally equal" individual formed by Western liberal political theory (Helmreich 1998:166). Moreover, since the only interactions between agents in Echo are trading, combat and mating, Helmreich concludes that Echo is "extraordinarily gendered," and the Echo-agent as resembling, "a masculine individual that masquerades as a universal organism" (Helmreich 1998:168).

The second technique, following, in part, from the first, is *agent-based systems*, which often also apply to GA's. Agent-based systems model individuals interacting in a digital world with behaviors that may be as "basic" as "eating" or "breeding", or as "sophisticated" as "communicating" or "cooperating". What some artificial life call "population dynamics" may thereby emerge, such as fluctuating predator-prey balances or, as Holland also suggests, trading complexes. But what is significant about agent-based systems, which is a core component to much of the work of artificial life, is that the "agents" in these digital worlds may "evolve", so that phenomena such as "speciation" – that is, the formation of new and distinct species in course evolution – or "interbreeding" – breeding between different "species" – may occur. Agent-based systems, then, do not necessarily involve GA's, yet they exhibit some of artificial life's basic tendencies to view things from the bottom-up.

Craig Reynold's *boid model* from 1986 - an artificial life simulation used as an example of emergent behaviors, in which the complexity of "boids" arise from the interactions of individual agents adhering to a set of simple rules – is an example of an agent-based system. Simply put, in Reynold's model, "flocking" agents, called boids in analogy to birds, follow simple rules for moving through space with each boid seeking to maintain a certain distance from the others while still moving forward. The result is the spontaneous formation of a flock of boids, with a supple coherence, yet chaotic dynamics, resembling that of "real life" flocks or shoals. The point is that such an architecture has no central controller, with the kind of behavior, such as flocking, "emerging" in interaction with the absence of some governing entity. Such kinds of agent-based systems, like Reynold's flocking algorithm, has, for example, allowed Langton to make an essential point about the "ontological status of various levels of behavior in such systems," namely, that even though boids are not real birds, "flocking Boids and flocking birds are two instances of the same phenomenon: flocking." (Langton in Johnston 2008:179).

The third and final technique that I want to include here is *cellular automata* (CA), which ties up the local-global transitions (that is, the bottom-up approach) of the two previous examples into a purely formal domain. A CA is a model that consists of a regular lattice-grid of "cells", each one of a finite number of "states", such as "on" or

“off”, while the grid itself can be in any finite number of dimensions. For each cell, a set of cells called its “neighborhood” is defined relative to the specified cell. In such a model, an array of logical cells, then, is computed with a set of simple rules for how each cell’s future state is affected by the current states of its neighbors. Or, put differently, CA’s allow for making “self-reproducing” loops, as each cell in the CA’s lattice-grid is a finite automaton whose state-transition table is defined by a single set of rules applied homogenously across the lattice itself. In this sense, the rules constitute, artificial life researchers say, the “physics” of a discrete, purely formal, space/time universe.

The best known, and most studied, CA is perhaps mathematician John Horton Conway’s *Game of Life* – a zero-player game, in which its “evolution” is determined by its initial state, and not by the “player” or its “creator”, requiring no further input from this state. In other words, The *Game of Life* is “reproducing” itself, not depending on some “outside” perturbation or force once it has been initiated from its initial state. The universe of the *Game of Life* is an infinite two-dimensional orthogonal grid of square cells, each of which is in one or two possible states: “dead” or “alive”, or, “populated” and “unpopulated”, respectively. Thus, cell formations emerge and disintegrate, oscillate and disperse across the two-dimensional orthogonal grid, as every cell interacts with its neighbors, as cells travel horizontally, vertically or diagonally adjacent to one another. Conway’s *Game of Life*, for example, has often been marshalled to offer visual evidence of how simple rules can generate complex patterns, that is, to show how the “emergence” of complexity arises from simplicity, or how lifelike dynamics arise from formal rules. As such, the *Game of Life* has been frequently invoked in arguments for the merits of the artificial life, especially in advocating for its bottom-up approach. Indeed, certain of its configurations have proven to some to be computationally universal (equivalent of Turing machines²⁵), meaning that they can be used to implement any finite algorithm and evaluate any computable function (Johnston 2008:10).

²⁵ A Turing Machine, named after the famous mathematician Alan Turing, is a mathematical model of computation that defines an, “abstract machine”, which manipulates symbols on a strip of tape according to a table of rules. It was, in part, used to demonstrate that despite the model’s simplicity, given any computer algorithm, that Turing machines are capable of simulating that the logic of algorithms can be constructed, and thus a conceptual forerunner to the modern computer. (Johnston 2008:8)

Now, while this first era, the “computer era”, brought significant technical and conceptual resources to the field of artificial life, including to lab members at the Ikegami Lab, who recycle many of these techniques, it “did not really,” Ikegami notes, “capture the essential part of what life is because even though you can mimic something: the forms, the appearance, and so on, on a computer, you still cannot make it in the real world. The real world is more complex than the level of complexity one finds in a computer, so complexity is something that is higher in the real world compared to a computer world. And while a computer can generate very high levels of complexity, the complexity is different from what you see in the real world.” Thus, in the course of the evolutionary trajectory of artificial life, the “computer era,” according to Ikegami, has mutated into the “second era”, an era he calls the “chemical era”. In this era, artificial life researchers, and synthetic biologists, alike began to play around with test tubes, petri dishes, microscopes and soldering techniques.

The Chemical Era

In the “chemical era”, many of the formal methodologies, strategies and techniques developed during the “computer era”, are recycled and slightly rearranged. However, what has changed is the “body”, or the “medium”, by which, and through which, artificial life researchers have tried to harness some formal property of life. In other words, the repertoire of logics used to think about life and the living, as those we saw in the computer era, remain somewhat intact, whereas the material mediums, by which practitioners have been trying to simulate or synthesize whatever aspect these they associate with life, have been replaced. Rather than using computational media, artificial life researchers here use carbon-based lipids or amino acids, to name only a few, that is, “wetware” materials that are put together in diverse configurations in order to further investigations of issues relating to the topics such as the “origins of life”, “autonomy”, “reproduction” and “evolution”, and more. It was at that time, as Ikegami says, “synthetic biology became less costly, and it was at that time we began playing around with chemical droplets that could move autonomously,” to which he concludes, “this became the second era.” The second era, or the “chemical era,” as

Ikegami names it, heralded fresh attempts not only at simulating, but at actually synthesizing (that is here providing a physical “body” to), artificial “living” cells, which also became known as the “wetlife approach” (Johnston 2008:270).

This shift in orientation, nonetheless, builds on an extensive body of research, in part from research conducted during the computer era, that has sought to understand the transition from nonliving states to living states, or how living matter “emerges” or comes-into-being from nonliving matter. Such a process, many artificial life researchers wonder, may potentially explain the “origins of life”, which also means that much of the research in the chemical era has been geared towards questions concerning how life basically took hold on the planet we often call “Earth”. But what makes such “wetlife approaches”, and associated research agendas, differ from computational experimentation - specifically of the sort pursued in the computer era - is the aim to synthesize, i.e. construct, artificial cells in laboratory experiments, despite the fact that these are different from any known form of life and therefore might not even recapitulate life’s actual origins (Rasmussen et.al. 2004:85). Such yet-to-be-constructed artificial life forms, or cells, have sometimes been referred to as “protocells” or “protobionts” – self-organized, endogenously ordered, spherical collections of lipids²⁶.

For example, the bacterium *Mycoplasma genitalium* is believed to contain the smallest genome for a self-replicating organism, and has thereby become a candidate for exploring a minimal gene set. Moreover, it has been estimated that the bacterium requires only about 300 of its 517 genes to function properly, which means that it can remain “alive” even after much of its genome has been eliminated. For biotechnologist and geneticist John Craig Venter and microbiologist Hamilton O. Smith, for example, this exact feature of the *Mycoplasma genitalium* has made it an especially enticing object of protocell research (cf. Gillis 2012). In their own research

²⁶ It is generally agreed-upon, however, still shrouded in controversy, that in order for a cell to be “living” it must be capable of regenerating itself, replicating and evolving, and that the processes by which this accomplished are located together within a single membrane, which thus constitutes a single entity: a cell. This consensus rests, in turn, on the further hypothesis that “natural” living cells are the smallest unit of “unquestionable” life, so that it constitutes a distinct threshold. More precisely, and to the point, a natural living cell is composed of separable molecular processes that are not in themselves alive, or at least not considered to be, yet when these processes come together they result in what we might call a living cell (cf. Johnston 2008). I also want to add here how such assumptions, although controversial, implicitly builds on ideas otherwise found in complex systems science.

on protocells, Venter and Smith have tried to remove the genome from a bacterium and then injecting into its nucleus an artificial string of genes, which resembles a naturally occurring chromosome. Doing so, Venter and Smith are hoping that the cell will not only survive, but also evolve into a new kind of cell equipped with new capabilities. Such a project may be said to be lodged somewhere between a top-down and a bottom-up approach in using “living” cells to make new, if not artificial, then quasi-living cells of sorts. This is, in effect, not a sort of reverse engineering, since it *Mycoplasma genitalium* is not “man-made”, yet it may count as a mode of “stripping” down natural compounds to their simplest elements to potentially reveal new functions.

In one, albeit more ambitious project concerning protocells, Ikegami himself, and his friend chemist Martin Hanczyc, have developed what they call a *first cell* as opposed to a minimal cell²⁷. While there is no solid consensus about what a protocell really is, and whether or not protocells really exist, some claim that a protocell must constitute a minimal form of life and/or meet some generally recognized biological life criteria. If these requirements are not met, protocells simply do not exist. Meanwhile, one might say, such disagreements themselves suggest that debates about protocells are definitional and conceptual tugs-of-war, since life scientists do not even agree on what the criteria should be to begin with. However, Ikegami and Hanczyc (who both call themselves artificial life researchers), perhaps needless to say, are not beholden to any biological definition of a protocell. In bypassing biological criteria, they suggest protocells already exist, and that they exist as primordial molecular globules formed from both organic and inorganic compounds, which are capable of self-organization and dynamic behavior. Protocells, according to Ikegami and Hanczyc, then, do not simply reproduce minimal, biological life, but are self-organizing processes subject to the laws of physics and chemistry. They are, in other words, terrestrial agents that possess some, but not all, of the properties of biological life, but that does not mean they do not exist. Nor does it mean that protocells should be evaluated according to the logics and criteria of biology. Their *first cell*, they argue, is the first “true

²⁷ A minimal cell is also called an “artificial cell”, which is an engineered particle that mimics one or several functions of a biological cell. However, the term does not really refer to a physical entity, but rather to the idea that certain functions or structures of biological cells can be replaced and/or supplemented with a synthetic entity. The first cell, developed by Ikegami and Hanczyc, by contrast, is a physical entity as well as an idea.

embodiment of artificial life” – a sort of artificial or synthetic life form built from the bottom-up, unlike the *Mycoplasma genitalium* of Venter and Smith – “that is an orthologous departure from the one familiar type of biological life” (Hanczyc 2014:1038).

What is at stake in this latter example, in contrast to the former, is precisely the issue of constructing artificial cells from scratch, out of nonliving organic and inorganic materials. Or, put differently, whereas Venter and Smith are removing some of the genome from a pathogenic bacterium, although with the aim of producing something new, Ikegami and Hanczyc attempt to construct the newly new from the very beginning, out of nonliving materials. This distinction is important, as I hope will also become apparent throughout this thesis, since it marks one of the central aims of the Ikegami Lab: to build new “living” things from scratch, from the bottom-up.

However, in the case of the first cell, one of the main problems in doing so, for example, is that the mechanisms of cellular metabolism and replication, with ensuing heritable variation, including self-organization and dynamic behavior, must somehow be made to self-assemble in the same confined space, so that such processes remain stored in the same physical container. Besides the experiment conducted by Ikegami and Hanczyc, however, there are several research programs afoot that are attempting to create a fully functional protocell, attempts that are characteristic of what Ikegami means by the chemical era.

The Third Era

Ikegami summarizes the third era as such, “first it was all about computer programming. Then it became about chemical experiments, but now, in the third era, artificial life has become a new technology. Developing this new kind of technology is not about optimization in the sense that it is about making everyday life easier, neither is about automatization of human activities, such as cleaning or office work, but about autonomy, and about creating things that can interact with the world in new ways.” This is essential to the third era, according to Ikegami, and not only that, it is

essential to the work of the Ikegami Lab, work that pushes the inventions of artificial life out of their digital prisons, into the “real world”, which is, as Ikegami asserts, “not just about words and theory, but about making hands-on experimentation. If programming affords you to understand what life is from actually programming it, the same goes for working with test tubes, microscopes, chemicals and robots.”

The third era, according to Ikegami, was primarily set in motion through what he calls a series of “technological revolutions”, starting in 2008 and picking up pace from 2010. In contrast to the futurist Ray Kurzweil, who spelled out the date of “Singularity” (or technological singularity) to the year 2045 - a revolutionary moment signaling a time when “machine intelligence” becomes irreversibly more powerful than “all human intelligence” combined - Ikegami rather sees these technological revolutions to be a series of events sparking, in more or less accidental succession of one another, the moment of Singularity. As Ikegami clarifies, “the past decade or so has seen a revolution in terms of the amounts of data that can be handled computationally, and the effects this has on science. This revolution began to gather speed around 2010 or so, and is ongoing now.” According to one of the most popular accounts of Singularity hypothesis, the so-called “intelligence explosion”, an “intelligent agent” will eventually enter a “runaway reaction” of self-improvement cycles that ultimately result in the agent’s own self-reproduction. And this “runaway reaction”, is implicitly embedded in what Ikegami associates with the third era, and era, when technologies that are constructed in the real world may potentially, Ikegami says, “try to escape us”. I will return to how this shapes up in practice later on in this thesis.

But for now, it serves to say that the third era has brought with it a proliferation of new technologies, Ikegami believes, which are fundamentally and necessarily provoking scientists to develop new ways to see the world. But new technologies, Ikegami thinks, also provide new opportunities and possibilities for experimentation, which are to Ikegami summarized in physicist and network scientist Albert-László Barabási’s (2011) book with the bombastic title *Bursts: The Hidden Pattern Behind Everything We Do*. To Barabási, the digital reality of our world, from mobile phones to the Internet and email, has turned society into a huge research laboratory.

Electronic trails of time stamped texts, voicemails, Internet searches, and more, Barabási observes, add up to a previously unavailable massive data set of statistics that track our movement, our decisions, and our lives (Barabási 2011). Thus, new technologies and our new digital reality reveal to us, Barabási writes, “how our nakedness in the face of increasingly penetrating digital technologies creates an immense research laboratory that, in size, complexity, and detail, surpasses everything that science has encountered before.” (Barabási 2011:10). And so, to keep with the language of taxonomy, Ikegami takes note that a series of “transmutations” have increasingly been turning our world into a massive, large-scale laboratory in the period between 2008 and 2012, transmutations that have fundamentally changed and altered our possibilities for conducting new research.

The ideas of both Kurzweil and Barabási, then, illustrate perfectly how Ikegami imagines the third era, in which new technologies may 1) “try to escape us” in the sense that they gain the capacity for self-reproduction and reach a level of intelligence surpassing humans, and 2) fundamentally change how we do science altogether. And so, Ikegami further segments this series of technological revolutions or transmutations into three classes.

The first class of events is the so-called, “Big Data Revolution”, Ikegami tells me, which essentially sprung from when an algorithm, made by the tech-company Google, solved the Rubik’s Cube in 20 moves. This opened many discussions between scientists about “God’s Algorithm” - the idea that algorithms may function as omniscient things that would know an optimal step from any given configuration. For 30 years or so, mathematicians had been grappling to solve the famous cube puzzle, concluding that the minimum number of moves required to complete the task was 22. While a popular mind-boggling pastime for some, for example Ikegami himself, the mystery of the Rubik’s cube had for long undergone sustained mathematical analysis. But nevertheless, God’s Algorithm is indicative to Ikegami that we entered a new era.

Then, in 2010, when a team of computer scientists and mathematicians gained access to Google’s supercomputers, they found that the minimum number of moves for any of the 43 quadrillion Rubik’s position was really a surprising 20. This result, Ikegami argues, is a reflection of the, “emergence of new technological capabilities in the last decade that are changing the world”. “I was knocked out by this Rubik’s Cube”, he

continues, “you don’t need group theory or any beautiful mathematical equation, but just a big table to solve it”. What God’s Algorithm specially reveals to Ikegami is that machines are not restricted to the same physical constraints and thus do not need to solve, say, a Rubik’s Cube, according to the same scheme as human beings. Machines, then, may be made to operate somehow like God’s Algorithm in the sense that they are directly socialized, communicating without the mediation of language or even sensorial experience. And this is also related to Ikegami’s notion of technologies “escaping us”, which leads him to propose, “So, I think humans are the bottleneck. In science, we don’t necessarily need human beings for understanding things. Humans need equations to understand what goes on, right? But computers do not. Big data to big data. Computers don’t need to be visual either, they don’t have eyes, but humans have to visualize the data. So, visualization and writing down equations is always the bottleneck, but after 2008, we really need to rethink about how we understand such phenomena.” What Ikegami is after is that we reconsider how to understand our world once more, especially when new technologies change the dynamics of our world.

Now, included in his first-class series of revolutionary events, Ikegami also points to Deb Roy’s “SpeechHome” project - a project involving the creation of an algorithm capable of tracking the development and context of words and phrases across time. Deb Roy, a computer scientist at the Massachusetts Institute of Technology Media Lab (MIT), had just prior to his son’s birth in 2009 installed eleven video cameras and fourteen microphones in his own home. The recordings were streamed to his basement and stored on a terabyte capacity disc array. With this system installed in his own home for over 3 years, every cry and giggle, diaper change, each chat or spat between Deb and his wife, were recorded and stored in more than 250,000 hours of video. The aim: Roy wanted to capture the whole process of his son’s language acquisition. But while there had been previous studies, based on anecdotal theory, about the developmental processes of children, none had involved, like Roy’s project, a longitudinal study with systematic recordings of a child’s everyday life.

Roy’s SpeechHome project offers to Ikegami similar evidence that algorithms can indeed operate to solve complex problems on their own. Furthermore, SpeechHome also echoes Barabási’s idea of turning the world into one big laboratory, as electronic trails, tracks and recordings provide us with a previously unavailable massive data set

of statistics by which we may track and analyze our movement, our decisions, and our lives, including how children learn, as in the case of Roy. Indeed, to the complexity-minded Ikegami, the results of the SpeechHome project reinforces his conviction that, “language acquisition does not only happen in one’s brain, but it is distributed in the space-time dynamics of a baby, care takers and the house layout. And this study [Deb Roy] also suggests that enormous datasets, including non-typical and those used anecdotally, are needed for unraveling complex phenomena.”

Lastly, still in the first-class, in the “Big Data Revolution”, Ikegami looks to biophysicist Philipp Keller’s lab, the European Molecular Biology Laboratory (EMBL), in which Keller and his colleagues have combined a technique called “light-sheet microscopy” with novel computational strategies to record early cell division, cell migration, and the emergence of early structures in embryos. In somewhat similar ways to Roy’s self-recording SpeechHome, Keller’s new laser monitoring system visually tracks and records the actual development process, not of a human child, but of a zebra fish, from the 64-cell stage to the 16,384-cell stage. And so, the actual cellular development of living things may be recorded and tracked in microscopic detail just like anything else in a global laboratory.

Now, to go a little fast, the second class of revolutions, according to Ikegami, refers to the “Software Revolution”, which he associates with Geoffrey Hinton’s “deep belief network”, a generative graphical model with which to train a neural network to probabilistically reconstruct inputs to perform indexing tasks such as classification. In other words, deep belief networks can be “trained” to perform certain tasks to become a sort of unsupervised machine learning model, which can assemble results based on more or less random inputs and iterative processes. Included in this second class is also Sakamoto’s blockchain technology, a recording technology chaining blocks through using cryptography. Blockchain technology, in its simplest of terms, is a time-stamped series of immutable record of data that is managed by a cluster of computers not owned by any single person or entity. Each “block” of data is secured and bound to each other using cryptographic principles (i.e. “chain”), which allows for digital information not to be copied but distributed.

These two examples of the second class of the so-called “Software Revolution” culminate in the third and final revolution, which is, according to Ikegami, the

combined “Software and Hardware Revolution”. To this final class, Ikegami adds the proliferation of technologies such as the iPhone 3G and Ross King’s “robot scientist” called “Adam”. The latter, “Adam”, is a system designed to “automate science” by condensing and automating complex laboratory research through automatically testing biological and chemical hypotheses. Motivated, according to Ross King, to increase the productivity of science, Adam can work cheaper, faster, more accurately, and longer than humans, and can be easily multiplied. And, to go back to Ikegami’s notion of the Rubik’s cube, Adam is another example of how humans are “bottlenecks”, since this sort of system, as King argues, may even allow for the improvement of science by enabling the description of experiments in greater detail and semantic clarity.

Common to all these examples, it should also be apparent by now, is that they somehow offer a sort of “proof” or “evidence” to Ikegami that new technological developments are fundamentally changing the material, ontological and epistemological conditions for how we conduct research and how we do science. Furthermore, the advent of new technologies, as Ikegami sees it, opens new fresh apertures for scientific inquiries about the world that force us to ask new questions. Thus, as Ikegami notes in relation to artificial life, if these new technologies make new conditions of possibility for doing scientific research, indeed allow for new ways to see the world, artificial life is not exempt from partaking in the construction of such new technologies. Artificial life, Ikegami believes, is equally in the business of changing the world by developing new technologies, such as robots, as we shall also see later on in this thesis, and by developing new theories and concepts, by which to apprehend our reality.

In this way, Ikegami’s series of technological revolutions are enmeshed in what anthropologists Margaret Lock and Vinh-Kim Nguyen (2010) see as a sort of techno-utopianism on behalf of science. As Lock and Nguyen note, technologies have historically been embroiled in various techno-utopian fantasies about the freedom, progress, prosperity or betterment of individual and collective life. And so, technologies, they further note, have in various ways been tethered to social, cultural, economic and political agendas summoning future dystopias replete with warnings about the detrimental consequences, as well as future utopias replete with promises

about the advantageous consequences to both individual and collective life (Lock & Nguyen 2010). To Ikegami, though, technologies are not necessarily tied to any economic agenda, nor necessarily a political agenda, but they are clearly tied to a utopian vision of science. They are, in other words, enmeshed in Ikegami's own scientific agenda about improving upon scientific possibilities for acquiring new knowledge about the world.

To this end, I want to suggest, the construction of new technologies is therefore, in Ikegami's imaginary, tethered to a utopian dream of *amplifying* the modes by which science is conducted. As such, the construction of new technologies is not, at least according to Ikegami, tethered to some commercial agenda, for example such as the extracting any commercial value. Nor is it connected to some ethical agenda in the sense of making public life better, whatever the word, "better", might here entail. The point is that the development of new technologies, to Ikegami, is *for science of science*, which means that construction and use of new technologies should be mobilized to ask new, fundamental "scientific questions". As Ikegami summarizes, "the impact of the 'Big Data Revolution' is spreading through more and more fields and is gradually changing the conventional natural sciences. Alife is not exceptional. In the field of Alife, we have developed several methods for optimization, such as ant colony optimization, particle swarm optimization and evolutionary computation, including genetic algorithms. But the data revolution presents new challenges." Such new challenges, in part, are about forcing upon that we ask new questions, and Ikegami seeks to integrate these ideas into the Ikegami Lab.

The Evolution of Artificial Life

What Ikegami's narrative of artificial life reveals, harking back to his diagram, is how the field's history may be considered in terms of evolutionary time by mapping the field's ancestry in a phylogenetic idiom. In this sense, insofar one plays on the logic of emergence once again, one might say that the Ikegami Lab itself "emerges" as a of complex dynamic system through an evolutionary path of social, scientific, and historical possibilities. That is, in an attempt to trace the intellectual lineages of their

field, the artificial life researchers are in the process of retelling the story of artificial life, which simultaneously allows them to ground their claims for the field not only in a venerable intellectual lineage, but also in a *genealogy*, even an explicitly *evolutionary* one leading up to the “third era”.

In telling their own story, then, a story I heard over and over again during my fieldwork, these artificial life researchers, unlike other scientists like synthetic biologists or high-energy physicists - scientists who tend to see themselves as ahistorical and uncultured - do *not* see themselves as either ahistorical or uncultured (Traweek 1988; Helmreich 2017; Roosth 2017). Rather, their lab is the result of a number of “transmutations” occurring through a longer history, and through a different set of “cultural” eras, which situates their enterprise not necessarily as different in kind, but as different in variation, as they insert themselves along an evolutionary path, or rather along several evolutionary paths in an effort to propel their field in forward-motion towards the newly new: to construct artificial life in the real world.

In narrating the “evolution of artificial life”, Ikegami exposes their enterprise is also tied prior approaches to the synthesis of life, not only from the “founding fathers”, but also to the principal avenues that have often been distinguished by the means employed: hardware (robotics), software (replicating and evolving computer programs), and wetware (replicating and evolving protocells) (Johnston 2008:3). In this way, I suggest, they simultaneously cast themselves to be the outgrowth of history and in the process of advancing their field in a forward motion that gestures towards the newly new and the yet-to-be-discovered. But key to this is the formulation of a desire to construct new technologies, which may aid them in the quest to better understand what life is and how it works. In other words, I want to maintain, their way of telling their own story of their field allows them to imagine that they stand on the cusp of a new accouchement built on, and indeed indebted to, a longer history of technoscientific discoveries and possibilities. Proceeding through Ikegami’s narrative, one notices that he seeks to capture some of artificial life’s many mutations, from the “computer era” to the “chemical era” to the yet-to-be-named “third era”.

Yet, each era is not replacing one another, but rather *adds* on to one another, which, in the language of complexity, means that the lab members allow complexity to build on complexity. Artificial life, according to this narrative then, has undergone shifts from seeing computers in networks as a form of artificial life to the laboratory creation of so-called “wetlife” as a form of artificial life. Thus, if the first era is characterized by efforts to simulate living processes in computational media, the second era is characterized by synthesizing living processes in chemical media²⁸, now leaving space for the third era, which is, according to Ikegami, to “construct artificial life in the real world.”

Finally, in their effort to gather up, or indeed add on, the many intellectual lineages and approaches of the “founding fathers”, through the many era, the lab members at the Ikegami Lab are somehow, I want to propose, *evolutionizing* their field, but they are doing so in order to set up the conditions of possibility of *revolutionizing* it: constructing new artificial life technologies from scratch, as we saw for example in the first cell experiment conducted by Ikegami and Hanczyc, is key to formulate radically new understandings of life, understandings that seek to shatter biological modes of reasoning. For example, as Ikegami and Hanczyc argue, “life” is perhaps better defined with respect to a certain physics, Or, put differently, if what characterizes agent-based models, biological ecosystems, economies and complex dynamic systems is that they “evolve”, that is, that they are systems active in time and space, so too may the stories Ikegami and the lab members tell forward-engineer a social version of their enterprise that has them scouting for new horizons of possibility.

Now, if this chapter addresses what they mean by the “third era”, and more specifically if this thesis addresses what they mean by their self-described mission to construct “artificial life in the real world,” the following chapters pursue some of the

²⁸ Along the way, however, two things drop out and remain unresolved: first, the issue of “simulation” in terms of questions concerning where simulation ends, that is, what are the limits of simulation insofar chemical experiments also serve as “simulations” of living processes that artificial life researchers associate with living activity? And second, the question of which particular material objects, with which living processes are harnessed, are best suited to demonstrate the viability of artificial life? Or, as philosopher Jean Baudrillard would have it, do simulations reveal that there was never an original, with simulations circulating without any reference to the “real”?

many meanings and entangled relationships of “construction”, “understanding” and the “real world”. In the following chapter, then, I first want to zero in on the Ikegami Lab itself to describe in more detail how some of the formal methodologies, strategies and techniques, including their associated discourses, which have been presented in this chapter, are being imported into the lab by the lab members. In other words, chapter 3 will take a closer look at the lab itself and introduce some of the lab members and their work. Here, I will examine in more detail how they construe the relationship between “construction” and “understanding”, a confluence I call *maker’s knowledge*.

3

MAKER'S KNOWLEDGE



Above: Julien Hubert, a postdoc at the Ikegami Lab, dabbling with a model. Below: The Ikegami Lab office space. Photo courtesy of: author.



Introduction: Constructing an Understanding

“You cannot understand the things you cannot build by yourself” Lana Sinapayen, a PhD fellow at the lab, tells me one afternoon. Lana, wearing a cuddly sweatshirt and jeans, adjusts the frame of her glasses and continues, “A Life is not just about defining stuff. It’s also about finding out what’s going on by building it.” Trained across the fields of engineering, computer science and artificial intelligence, Lana describes herself as, “a programmer by heart”, who have become an artificial life researcher at the Ikegami Lab to pursue her goal, she says, of “understanding things like intelligence and life by building them.” Prior to becoming a PhD fellow at the lab, Lana had accumulated an impressive skillset which had enabled her to program in just about any programming language: Java, C++, R, C, Objective C, PHP, JavaScript, Python, Swift, Lua, Ruby. She is, however, “an Alifer”, who is now putting her skills to use in an effort to better understand some of the fundamental workings of intelligence and cognitive complexity, as pertaining to how living systems learn to adapt to complex environments.

Outside her PhD research, Lana has, “a million of research interests”, and therefore engaged in “a million projects” some of which, she tells me, are about building, “cute amphibious robots to track river fish,” and about doing “experiments on bonsai trees and petri dishes with tardigrades or mold colonies”. Lana’s pastime activities, it occurred to me during fieldwork, fused well with how she conducted her research, where she was dabbling with ways to explore and develop new neural architectures for adaptation to complex worlds²⁹. Her “artisan” identity, handy profile, coupled with her descriptions, hobbies and spare-time activities, became to me emblematic of how many of how many of the lab members at the Ikegami Lab preferred to approach their research questions: building things, such as amphibious robots, computer models, androids, and so on, is a way to ask questions about other things, such as life, intelligence, cognitive complexity, and the relations between them that would not

²⁹ In her PhD project, for example, Lana asks the question on how to program a machine to “adjust its cognitive complexity to the environment so that prediction emerges from action and classification emerges from prediction?”, by which she explores, through her work on artificial neural architectures (based on biological neural architectures), how to make algorithms to help machines learn from complex input to produce “appropriate” outputs while optimizing the computational cost.

previously available to them.

What Lana taught me during fieldwork was that *constructing* stuff, that is, by building new computer models or amphibious robots, was not simply an end in itself, but rather a way to explore things and ask questions about them. Building models and amphibious robots is a way to explore issues and questions about intelligence or cognition, categories I otherwise think of as somewhat intangible and abstract, not something that can be materially constructed. However, for the lab members at the Ikegami Lab, such categories of “intelligence” or “cognition”, which they often associated with “life” and the “living”, I reckoned during fieldwork, were seemingly *constructible categories* knowable through the material construction of models and systems.

Now, if the ethos behind artificial life is animated by the attempt to abstract the logical form of life in different material forms, particularly in computational media, then this definition holds that formal and material properties can be pried apart and what matters is *form* (cf. Helmreich 2016). And if, as Lana suggests, construction precedes or is simultaneous with understanding, then it is readily apparent that the question about *what* gets made, needless to say, is tethered to the what kind of questions they are asking. That is, the things they associate with life and living, or more specifically with life’s form - such as information, intelligence, evolution, homeostasis, adaptability, cognitive complexity, memory, self-organization, etc - are here not simply abstract categories that are good-to-think-with (cf. Lévi-Strauss 1995; Haraway 2003). Rather, such categories can be *built*, materially, technically and algorithmically, which means that such *abstractions*, for example like homeostasis (a concept that explains how living systems sustain themselves through physiological processes), are at the Ikegami Lab rendered *empirical* in order to be materially constructed, investigated, reengineered, and rechanneled (cf. Helmreich 2016:xx). It is through construction, then, that the lab members seek to understand certain aspects of what they associate with life and this is a central element in their practice, as Lana herself notes, “you can only know what is really significant to life by building it yourself.”

In this chapter, I want to take a closer look at what the lab members mean by this confluence of “construction” and “understanding”, of making and knowing. More

generally, I seek to unpack how some of the elements explored in the previous chapter are disseminated in practice and in discourse at the lab by specifically showing how the lab members at the Ikegami Lab seek to approximate a better understanding of life by constructing new models or by revamping older ones. Making models, as Lana and others claim, is a way to query what they call the, “information layer of life” – an underlying domain, in which they hope to make visible some fundamental principle of life, which may only “emerge”, they say, through constructive experimentation. As Lana also exemplifies in this introduction, the lab members generally believe that the best way to *understand* something about life is by *constructing* it, which means, for example, that the best way to understand how homeostasis works is by constructing it, exactly by building a model or some artificial system of it.

Thus, if the core idea of making or constructing, as philosopher Ian Hacking (1999) puts it, “is that of building, or *putting together*” (Hacking 1999:49 *my emphasis*), this chapter focuses on how the lab members are putting together new models. In this putting together, they are also remaking older models or revamping them to ask new questions about life and the living. In practice, this means that the lab members at the Ikegami Lab either construct new models or revamp older ones either in order to refine current knowledge about life or to make new claims about it, which would otherwise be impossible without the work of construction in the first place. And by doing so, it is readily apparent that construction, or the actual putting together of stuff – the putting together of algorithms, information and material substrates - *is* the royal road to understand how life works on a more profound level.

The confluence of making and knowing, or between “constructing” and “understanding”, then, here constitutes what I call *maker’s knowledge*: the powerful knowledge that can be forged only by constructing (rather than finding) something new. Maker’s knowledge is thus an analytic term I use to unpack the relationship between construction and understanding, which are two elements that cannot be separated when it comes to how the lab members work. As such, maker’s knowledge also offers an intriguing resonance with science studies literature on the what might be called the “social construction of x”³⁰, proliferating through the so-called “science

³⁰ Where “x” may equal, for example, “technological systems” (Bijker et. al. 1989), “scientific facts” (Latour & Woolgar 1986), or “validity” (Bowden 1985), and so on.

wars”, which has been waged over the contested construction of scientific facts (Hacking 1999; Traweek 1996). But here, however, maker’s knowledge takes the idea of construction to another register. As Lana and the other lab members reveal, they do not seek to hide the fact that things are constructed, indeed, they are very explicit about how things are constructed, and whether their constructed objects are pushed to be “facts” or not, they are nevertheless *thoroughly constructed*. More precisely, the lab members are overtly explicit about their desire to *construct life*, or at least some aspect or feature of it, both materially and conceptually, and in their efforts to do so, plainly admit that they are indeed constructing it. This essentially underwrites, I think, that their constructive approach to vitality, by which I also mean that ideas, or “facts” of life, are indeed constructive categories, both materially and socially. But to better understand how maker’s knowledge comes about, one must first understand what the lab members mean by the so-called “information layer of life”, which may be “accessed”, they say, by making models.

The Immortality of Information

The “information layer of life”, or what Olaf Witkowski - a former PhD fellow at the lab, now working as an affiliated scientist at ELSI – also refers to as the “info-dynamics of life”, is a special, underlying domain, which may be said to be prior to, and the basis for, all modes of interaction. “So, making computer models”, Olaf further reports, is a way to query and study this “layer”, in which, “information” is the common substance or thing animating all living and nonliving things. As such, “information” is the common currency, a sort of “meta-value”³¹ that underlies and cuts across all instances we might term “bodies” or “organisms” occupying the material world. At least, this is what many lab members at the Ikegami Lab believe.

Thus, to better understand how construction precedes, or is simultaneous with, understanding at the lab, it is also crucial to remember how artificial life is commonly

³¹ By meta-value, I here mean those values and foundations upon which people recognize and accept their obligations to one another, and understand themselves and their positions in the cosmos (Rappaport 1999).

focused on the “organization” of matter, and not necessarily matter itself. As such, it also makes sense for many artificial life researches, including the lab members at the Ikegami Lab, to say that they study how matter is organized and not vice versa. As Olaf notes, “we do not study life directly,” but rather, he continues, how the informational patterns and structures of life are “organized”, both within and in between what many of the lab members gloss “complex dynamic systems”. Olaf summarizes his point, “rather than studying life directly, we’re studying the info-dynamics of life, you know, how life is organized informationally.”

In their commitment to the so-called “information layer”, then, many of the lab members are often hesitant to define living systems in any absolute sense. That is, as I experienced during fieldwork, many the lab member seemed to care less about spending time on vacillating on questions about whether this or that is in fact alive. Whether rocks, volcanoes, toasters or butterflies are alive or not is not really the question (while most of the lab members would most likely agree that butterflies are “more” alive than toasters). But what is of importance, however, is what these “complex dynamic systems” share, namely *information*. Information, I found during fieldwork, is the single, unique substance or entity that governs and directs interaction and that by which relations are forged. For example, as Lana explains, “everything has information in it, but we don’t necessarily consider it as life,” a statement which is further bolstered by Nathaniel Virgo – a trained chemist, former member of the Ikegami Lab, and now Olaf’s friend and colleague at ELSE - who on many occasions during my fieldwork attempted to elaborate on this point made by Lana. Nathaniel, who had migrated to the Ikegami Lab, and later to ELSI, from the University Sussex, tells me, for example, that Prigogine’s hexagon or Karman’s vortexes, are complex and emergent phenomena that may appear as both as examples of what the lab members call “emergent phenomena” and of “dissipative structures”, which are basically entities that not only display behaviors that may seem “lifelike”, but whose structure and behavior is organized by information.

Of course, as Nathaniel further reassures me, such types of phenomena, like Karman’s vortexes, are not really alive, but nor are they completely “dead” or entirely calculable or predictable in how they emerge and/or dissipate. Yet, still, whether they are really alive or not is still not really the question. What matters to Nathaniel is really how

they *emerge* or how they *dissipate*, that is, how they are *informationally organized*. And this is what is of primary significance to the lab members. Specifically, what characterizes both types of phenomena, living or nonliving, and besides being emergent phenomena and dissipative structures, is that they may also be defined as dynamic informational patterns that are active in time and in space. Thus, information is what both living and nonliving things share, and as such, it is by this very virtue itself that they may at times, assume qualities that may appear “lifelike”, despite the fact that they may initially be “nonliving”. Still, this does not necessarily mean that they are truly alive, and neither do any of the lab members claim them to be.

Their focus on emergent phenomena and dissipative structures, then, or more broadly the “info-dynamics of life”, is perhaps best exemplified by the words of Nathaniel, who exemplifies how to construe the boundaries between the “living” and the “nonliving”,

So, in the case of a hurricane, for example, it only forms under certain conditions: low wind, large collections of thunder storms in the same space, the wind has to be sort of swirling a bit, and once you have those sorts of conditions you get a sort of proto-hurricane that becomes a fully developed hurricane. And that fully developed hurricane can then move around and persist in areas of the sea where hurricanes would never form. Similarly, a human being can be formed only in very specific circumstances if having a fertilized human egg in a human womb, and then a family to feed it, and once this has happened the human being can then go on to survive on its own, in a forest if it needs to, or it can get a job and live in the city, or whatever, there are many other places you can survive than places you can be formed. And that’s something that can be true to degrees, but it’s a quite common property.

Now, of course, neither Prigogine’s hexagon, Karman’s vortexes or Nathaniel’s hurricanes, are normally considered to be “living”, nor are they synonymous with Nathaniel’s “humans” or “fertilized eggs” (although it may seem so from Nathaniel’s description). Rather, what Nathaniel wants to point out is that what matters here is to mark the specific conditions of possibility for a hurricane *and* a human being to

emerge, exist, and disintegrate in the first place, despite the fact that their conditions of possibility may, however, be both radically and qualitatively different from one another. And, still, what humans and hurricanes share, or have in common, Nathaniel seems to suggest, is that they may both be seen as complex dynamic systems, as bundles of informational or codified entities fundamentally sharing some core affinities due to the fact that they are both organized informationally.

Nathaniel's analogy between the living and the nonliving, I think, is based on the axiomatic existence of information, as the basis for any interaction or any emergence. And this way of talking about the life, the living and the nonliving is common to how the lab members generally think and talk about their work, about complex dynamic systems and so on. A hurricane, for example, cannot itself maintain its own equilibrium, but dissipates as soon as the "external" forces upholding it are removed. Similarly, humans, or at least human bodies, maintain their own equilibrium in relation to a number of "external", or "environmental" conditions and variables upon which it is contingent, however, in extreme environments, outer space or deep sea, human bodies would easily "dissipate". And as such, as Nathaniel concludes, both types of phenomena, hurricanes and humans, are fundamentally "precarious, spatially individuated dissipative structures," that "may remain constant over time due to a precarious balance between reaction and diffusion processes." The point being here that virtually everything, if one asks a lab member at the Ikegami Lab, may be considered to be a complex dynamic system regardless of ontological and qualitative differences; what they share, living or nonliving, is that they are organized, maintained or broken down informationally.

Hence, what the abovementioned phenomena share, regardless of whether they are defined as living or not, is that they are organized and/or maintained in a delicate and highly precarious series of processes, which make up the conditions of possibility for their respective "individuation": they persist, in other words, by consuming, as Olaf would have it, "free energy" from their environment (producing entropy) and thus they have a sort of, "Ship of Theseus"-property that have them persist despite every atom being replaced. Yet, as dissipative structures, they are always-already precarious, always-already at risk of dissolving or disintegrating insofar they are no longer able to keep in sync with the environment (or to use a biological phrasing: to

“metabolize”). All the lab members, I found, describe different types of phenomena in this way, indeed, all them believe that information is the basis for all forms of organization. But this is not to say that they do so without claiming that all phenomena are the *same*. Rather, on the contrary, various phenomena are, of course, *different* from one another (hurricanes are not humans), so the key is to locate and identify the local *differences* to how things emerge, the particular circumstances by which phenomena are sustained³².

Such ideas, render meaningless any absolute definition of a living system, since many “nonliving” systems, according to this logic, may equally share features or characteristics of living things. And as such, it makes no sense, as Lana explains, trying to make any absolute definition of “life”. She reports,

Trying to define life using science is a waste of time because life is a subjective concept rather than a scientific one. We call some things ‘alive’ that we do not understand, but when we gain enough insight about how it works, we stop believing it’s alive. We used to think volcanoes were alive because we could not explain their behavior. We personified gods, things we could not comprehend, like seasons and stars. Then science came along and most of these gods are dead. Nowadays science doesn’t believe that there is a clear-cut frontier between alive and not alive. Are viruses alive? Are computer viruses alive? I think that the day we produce convincing artificial life, the last gods will die. Personally, I don’t bother too much about classifying things as alive or not; I’m more interested in questions like ‘can it learn?’ How?, ‘Does it do interesting stuff?’, and so on. I’m very interested in virtual organisms, not so much viruses.

Lana reflects here a vision shared by many of the other lab members, who are largely uninterested in defining life as such, not necessarily because it is a waste of time, as Lana opines, but rather because they want to make what Olaf calls “qualified guesses” about what life is and what it could be. To Olaf, then,

³² In fact, I believe this is the crux of how artificial life researchers tend to think about the phenomena: all things are ontologically *different*, but they may be epistemologically imagined or thought of in roughly the *same* way, according to the same framework or logic. However, I will not go further into this in this thesis, but would nevertheless be curious to learn about more critical accounts of the epistemological orientations of artificial life and complex systems science (?).

making qualified “guesses” means to approximate more accurate assumptions about life, that is, to make more probable exactly how life, or some feature of it, emerges.

In order to make qualified guesses, then, they turn to modelling. By making a model of some phenomena, Olaf tells me, they may then come closer to discern some feature of life. A model, Olaf says, is a “box” (i.e. a computer model) that can be manipulated and opened and there a way to make qualified guesses about very complex phenomena. He reports,

All kinds of processes in nature are well understood because we could model them. Self-replication and so on. And it’s so fascinating that you can do this in a ‘box’, in a computer, with all the parameters. It’s much better than guessing what happens in nature. For very complex evolutionary processes, we’re still guessing though, but it’s better that you do this guessing in a box.

Historian of science Peter Galison (1996) has noted in his discussion of nuclear weapons research at Los Alamos, that computer simulations proved crucial to study problems too complex to solve analytically and impossible to investigate experimentally (Galison 1996). This situates, Galison notes, computer modeling work somewhere between theory and experiment, since models, on the one hand, resemble theory because they could animate processes of symbolic manipulation, and on the other hand, experiments because they could display stable results, replicability and amenability prone to error analysis procedures. For Olaf, who expresses that evolutionary processes are too complex to make unsupported guesses about, yet while also still too complex for simulation work, such a process is nevertheless still better understood in a “box”.

Galison further notes in his account of nuclear weapons research, that “computers began as a ‘tool’ – an object for the manipulation of machines, objects and equations. But bit by bit (byte by byte), computer designers deconstructed the notion of tool itself as the computer came to stand not for a tool, but for nature itself” (Galison 1996:156-157). On this view, theories, for example, can be tested with reference to an artificial reality conjured within the computer to the point of being just as good as the

real deal. However, on the contrary though, just as the lab members at the Ikegami Lab are reluctant to define living systems in any absolute sense, none of them ever claimed during my fieldwork that computers were anything other than tools or instruments.

Among the lab members, rather, computers are not considered substitutes for “nature” or “reality” per se, (which is also readily apparent from their self-described mission to construct artificial life in the real world) (cf. Helmreich 1998). Quite the opposite, computers at the Ikegami Lab are “tools”, indeed highly effective and propitious tools, with which to make better “qualified guesses” about some “external” nature or reality, or some kind of “natural” process, but they are not to be mistaken for the real deal. In other words, computers are tools with which to “access” and “query” the “information layer of life”, as Olaf tells me,

It is obvious for Alife that there’s a layer of information. So, you study the information dynamics, and not real life directly. You know the slogan, ‘artificial life is not studying life, but life-as-it-could-be’, it’s a bit like this. In the information layer, everything is information, and you can measure that. So, you have this layer of information and you study this layer of information instead of studying whatever processes are active in biology, and so you model those instead!

The way you “measure things in the information layer,” Olaf continues, is done by making simulations, which are supposed to somehow capture some informational dynamic or pattern of life, which can in turn be used to infer more qualified guesses about how it actually works. Olaf makes this view vividly clear when he specifies what he means by how models can “access” and “query” the information layer, of life, saying, “making simulations is really like you put on your glasses and you see flows of information, like you see this information layer, you see the Matrix!” Here, Olaf alludes to the Hollywood-blockbuster movie, *The Matrix*, from 1999, invoking a scene in which Neo, the film’s protagonist, is told by his mentor, Morpheus, that, “the world you see is the world that has been pulled over your eyes to blind you from the truth [...] Unfortunately, no one can be told what the Matrix is. You have to see it for yourself” (*The Matrix* 1999). When Neo “sees” the Matrix, a stringy code pattern that makes up the really real, the film plays on the idea that the “real world” is simply a simulation, a massive hologram, in which those living in it are unaware that it is, in fact, a simulation, i.e. that their reality is governed by some underlying algorithm.

While Olaf’s allusion to the Matrix is, of course, a metaphor, it is also meant as a joke. But tied into his ocular metaphor, nonetheless, is the fact that the lab members do not study “the nature of life itself”, as Olaf tells me, “but rather the info-dynamics of life, from one step away.” This “one step away”, which may give the impression that artificial life’s “counterparts”, biologists, those who study “the nature of life itself”, are somehow lost in Plato’s cave in looking for small inconsistencies in the shadows that they take for reality. For the biologist, to put it crudely, things are how they appear, which is to the artificial life researcher in fact a superficial spectacle, as a scene in *The Matrix* where a cat runs across a threshold twice, suggesting a glitch in functioning of the matrix itself. Again, while Olaf self-consciously uses *The Matrix* as a metaphor, I think it reveals, albeit in a metaphorical way, something about the way they “see” the work they do, digging into the “information layer of life”.

From this metaphor, too, one may mediate on the whether these artificial life researchers believe to have arrived at some idea of an “obvious true reality”, which not only grounds the epiphenomenal interactions outside the cave, the sort of interactions we, as humans are engaged in, but also levels how one may think and talk

about the living and the nonliving, as instances of the same process of information exchanges? Or, rather, to follow Olaf a bit further, it seems that this underlying, and seemingly axiomatic layer, undergirding any form of interaction between entities, is not really a hidden at all. The existence of a “layer of information”, as Olaf asserts, is “obvious” to an artificial life researcher. But what makes this obvious and self-evident, I want to contend, is exactly the construction of computational simulations and models.

Such informatic visions of vitality are prevalent among the lab members at the Ikegami Lab, even to such a degree that it underwrites a structure of feeling among them, a sense that the informational dynamics of life are truly immortal. Hurricanes and humans, to take just two types of phenomena, are fragile and precarious instances of informational dynamics, or as Olaf puts it, they are systems that exemplify the inherent logic of artificial life, “you give and take information, and you can apply this view to every kind of interaction, between humans or between humans and robots, or between machines, too. In a theoretical way, you can channel information through a noisy channel and you can receive and understand what it means.” All things, in other words, participate in a massive, large-scale economy of information. Now, to better highlight how this “applies”, following Olaf, to “every kind of interaction”, I now want to turn to how the lab members apply and build this logic *into* their own models.

The Map is the Territory

In chapter 2, we encountered computer scientist and artificial life researcher Craig Reynold’s so-called *boid model* from 1986, a model used as an example of emergent behaviors, in which the complexity of “boids”, analogous to “birds”, arise from the interactions of individual agents adhering to a set of simple rules. Reynold’s boid-model has gained much traction at the Ikegami Lab, both for its relative simplicity and as an appropriate testing ground for up-scaling and amplifying it in terms of size and complexity. Among the many projects ongoing at the lab, Ikegami and Olaf had prior to my arrival done a research project using Reynold’s model, where they had set about to amplify the model, both in terms of complexity, size and scale, in order to

explore the possibilities for new discovering the emergence of new patterns of self-organization and structures.

More specifically, by tweaking and remaking the boid-model, Ikegami and Olaf increased the size of the “flocks”, which in turn revealed to them that, “flocks are intrinsically unstable, and they will spontaneously collapse and reorganize, repeatedly. The sizes, forms and dynamics differ from one flock to another. When we increase the number of agents, new flocks emerge. Assuming that many agents live in a large space, different flock forms will spontaneously organize in different spatial locations.” In short, by simply increasing the complexity, size and scale of Reynold’s model, which is here a template for the model made by Ikegami and Olaf, equals, they suggest, the emergence of new patterns and structures. From this, Ikegami and Olaf further analogize that, “flocking is collective behavior of active agents, which is often observed in the real world, for example, swarm starling birds. In nature, swarms possess remarkable properties, which allow many organisms, from swarming bacteria to ants and flocking birds, to form higher-order structures that enhance their behavior as a group.” And, because such “remarkable properties” can be simulated, Ikegami and Olaf reckon, they may in turn help to make more refined claims possible, that is, enable them to articulate and define flocks and their boundaries in a more rigorous way.

Now, harking back to Olaf’s notion of “guesswork”, or the making of qualified guesses, the kind of “guesswork” done here, one might say, is extracted from revamping older models in order to discover something new. That is, without revamping the boid-model, Ikegami and Olaf simply could not, I will claim, have arrived at the conclusion that new emergent patterns and structures arise. On the one side, their revamped boid-model materialize the logic of artificial life in the sense that what matters is how informational dynamics organize collective behaviors, and as such, the logic shared among the lab members is put into practice. But on the other side, the sort of “guesswork”, if we stick to Olaf’s terminology, admitted by the boid-model, is authorized, I further to claim, by an argument of *isomorphism* (cf. Laqueur 2008).

Isomorphism, as historian Thomas Laqueur (2008) has noted, “comes from chemistry and geology”, where different isomorphic substances crystallize in the same “form”, or from mathematics, where isomorphism denotes the identity “of form ... between two or more groups” thereby authorizing certain operations (Laqueur 2008:51). On Laqueur’s account, to exemplify what counts as an isomorphic relation, he refers to Max Weber’s claim of an elective affinity between Calvinist Protestantism and capitalism, which may be said to be an operation animated and authorized by an argument of isomorphism. Likewise, as Laqueur demonstrates in the anthropological tradition, Clifford Geertz’s claim to read the most salient features of Balinese society in the niceties of a cock fight might also count as an isomorphic relation (Laqueur 2008:52; Geertz 1971). Or, as I will claim here, Olaf and Ikegami here read the most salient features of informational dynamics in the flocking patterns of digital birds.

Yet, this is not to say the boid-model made by Ikegami and Olaf is automatically isomorphic with what it purports to represent, i.e. flocking patterns or flocking behaviors. Rather, I maintain, it is actively *made* to be isomorphic in the sense that it crystallizes the phenomenon called “flocking” in the same form: the flocking of boids and of real birds, as Ikegami and Olaf would have it, are two instances of the same phenomenon, namely flocking. On this account, then, the map becomes identical with the territory insofar the map is flocking behavior, but it becomes identical exactly because Olaf and Ikegami make it so. Again, if one keeps in mind that the lab members are largely uninterested in whether toasters or birds are living or not, what matters here is not how accurately boids mimic birds, but how well boids exhibit the same forms of behaviors as birds, namely flocking. In short, the boid-model is authorized, following Laqueur, by an argument of isomorphism.

As such, Ikegami and Olaf do not consider their revamped flocking simulation as “proof” or “evidence” of some real instantiation of life or the living, or, for example, claiming that artificial life is possible in non-biotic substrates, i.e. computer models. Rather, as historians, philosophers, and anthropologists of science have also recognized, they are using their boid-model to materialize theories and concepts that they associate with living activity (i.e. information), which in this case is the form of flocking behavior, which makes their model function as both a representation of

scientific thinking and a tool for guiding research (cf. Sismondo 1999; Morgan & Morrison 1999; Keller 2003; Chadarevian & Hopwood 2004). Yet, still this does not necessarily mean that they are absolute “proof” of artificial life itself (i.e. that it is possible to construct real artificial life), but simply that their boid-model materializes what they associate with life or lifelike activity, namely, in this case, flocking behaviors, which is of course done by making analogies between boids (the artificial) and birds (the natural). Nor do they claim that their model is “life itself”, but rather use it as a pointer to possibility that certain features, properties, behaviors or processes of “life” can be successfully simulated in silico. Either way, I maintain that their argument is animated and authorized by an argument of isomorphism.

Now, if their boid-model is, however, a sort of digital double, a crude artificial representation of what they associate with natural processes, it is made, as philosopher of science Sergio Sismondo (1999) writes, “to stand between worlds, and pushed one way or another” (Sismondo 1999:258). But while it is pushed to stand between worlds through an argument of isomorphism, the boid-model does not itself *assume meaning*, but it is rather, I suggest, pushed to correspond to things in nature, thereby becoming a sort of actualization of flocking behaviors. That is, as already hinted, the boid-model is actively pushed to make a claim about how, in a computational and artificial sense, to define flocks and their boundaries in a more rigorous way. And this claim, I want to assert, would not have been possible without making a model in the first place.

To be sure, for example, making, say, an agent-based model (not necessarily a boid-model) with a spatial distribution of “food” and “agents” in order to uncover how agents evolve so-called “signaling systems” that improve their ability to efficiently gather and use the environmental resources in order to “improve their fitness”, might, according to this logic, be also *made* to correspond to how “natural” agents do so in “nature”. But what I want to put forward here is that this kind of work to make claims *from* models signals a confluence between construction and understanding, what I will from here on term maker’s knowledge: the sort of knowledge generated exactly upon constructing something new. In short, models do not automatically assume meaning, nor do they speak for themselves, rather, they have to be actively interpreted and shaped to those who make them, pushed into isomorphic relations.

Whether the dynamics or principles of their agent-based models at the lab are analogized to “nature” or not - or perhaps rather analogized to their conceptions of nature - or simply an exercise in exploring to which extent such dynamics can be simulated computationally, models are, nevertheless, the crux of the matter in relation to what kind of knowledge that can be produced and what kind of claims that can be made. However, on the contrary, not all lab members want to make claims from their models as such, as Lana, for example, makes it clear to me when she explicitly states that she does not want to make any analogies to some external world or Nature with capital N. “I absolutely don’t care about the realism of this model,” she tells, “I am more interested about what happens!”, suggesting the ambivalent status and function of simulations, as pointed out by Sismondo.

To which degree, or to what extent, models are supposed to imitate some external reality, in other words, is not equally of concern to all lab members. Whether virtual agents, often vying to survive in the self-made models, correspond to any “real” natural agents, say, whether a simulation of a virus actually corresponds to a “real” virus, and so on, it not always of importance to the lab members. Still, what is of significance to them is really whether the *dynamics* of their models can offer fidelity to the “real world” dynamics, whether these are actual or imagined, one might say. More precisely, whether the “behaviors” exhibited by a population of digital organisms really correspond to those observed among biological organisms, need not be of any significant importance. To this end, it is not whether the digital agents are accurate depictions of real biological agents, but rather whether the dynamics of the system, including the behaviors of the agents in them, are more or less accurate depictions of the *properties of what the lab members themselves define*.

If computers, or models, finally, as anthropologist Stefan Helmreich (1998) has shown in his own ethnography, may be “worlds” in and of themselves, capable of mimicking some property or feature of what they associate with life (cf. Helmreich 1998), some lab members seek to make alternative universes, which have no concrete reference to anything “real”. If computers, or models, occupy an ambiguous space between experiment and theory, as both Galison and Sismondo note, that is, “given the status of tools, as well as representations”, that may “easily cross categories, such as ‘theory’ and ‘experiment’, the bound of which are otherwise well-established”

(Sismondo 1999:247), they may also be used to cross boundaries between the real and the unreal, the real and the imagined. What I will simply claim here before going on to explore another model made at the lab, which is itself about exploring new territories, is that what allows the lab members to make claims *about* life is the active construction a model from which they may force out some corresponding identity between two otherwise separated categories. Now, while we have seen how the boid-model is pushed to refine knowledge about flocking behaviors, I now want to turn to another model, which is equally pushed towards making new claims. However, this model is not about making a claim about the emergence of flocking behaviors, but rather about how evolution, or more specially “open-ended evolution”, might work.

The Dream of Open-Ended-Evolution

From the first early computational experiments with so-called digital evolution in the 1950s, often associated with John von Neumann’s work on CA’s, to the increasingly sophisticated simulations of the present day, artificial life researchers, including the lab members at the Ikegami Lab, have collectively come to focus on issues related to the concept of Open-Ended Evolution (OEE). At the Ikegami Lab, Julien Hubert – a post doc at the lab and a trained computer scientist from the Vrije Universiteit Amsterdam – described the artificial life’s ambitions to construct a full-fledged simulation of OEE. The set of questions some of the lab member attach to OEE is summarized by Julien, who reports,

So, the ambition of Open-Ended Evolution is clearly to figure out how we became so complex, how animals became so complex, and why evolution, in a basic sense, stagnated. Why did humans become so much smarter? Why do crows use tools and grow smarter? And how did we get stuck in evolution? That’s something that is very basic to OOE. The goal, of course, is to understand life: what are the elements in life that actually led us to where we are now? Is it because of diversity? Convergence? Is it because the environment keeps changing and we have to adapt to it? Is it because we need to let it evolve for longer, like for billions of years? So,

in a way, the question is: how did we adapt to become more complex?
That is what people here want to get at.

OEE is basically the idea that evolution progresses not according to the logic and principles of Darwinian evolution, but by ever overcoming itself in generating more complexity and novelty in highly creative ways. OEE, I experienced during my fieldwork, had largely been slipped in through the backdoor, becoming a concept, which many lab members took to be the true theory of evolution. Lana bolsters Julien's summary,

A lot of people agree that Earth is probably an open-ended world. This means that from the time life appeared, it has always grown more and more complex with time, constantly producing new innovations. Today, we have very complex forms of life, which appeared from simpler forms of life as an effect of evolution and natural selection. The dream of OEE-researchers is to build such a world in simulation. But it is much more difficult that sounds... In short, OEE is about building a living world that is forever interesting.

A somewhat simple definition of an OEE-system, then, is that such a system would require that the maximum complexity of organisms in the system itself increases over time, or, in other words, that the complexity of its "ecosystem", that is, the entire system, increases indefinitely. Some of OEE-definitions were at the lab taken directly from the computer scientist Kenneth Stanley (2018), who is himself a strong proponent of OEE-research. Stanley writes that,

life has continued its evolution into virtually endless diverse and often increasingly complex forms for more than a billion years. Photosynthesis, flight and human intelligence are but a tiny sampling of the boundless feats of evolution, often far exceeding anything yet built through human engineering. In short, evolution on Earth is as close as we have seen to a never-ending algorithm – a prolific generator that continues to invent and diverge over eons without ceasing (Stanley 2018:7)

An OEE-system, according to this capacious, and highly computationally inflected definition, is a system capable of producing a continual stream of novel “organisms” and “behaviors”, rather than settling on some quasi-stable state beyond which nothing new occurs. Put differently, in a certain sense, the revamped boid-model of Ikegami and Olaf can, in comparison, be considered to be a sort of OEE-system in the way new flocking formations and patterns keep emerging upon one another. That is, a system that allows for complexity to build upon complexity through its own creative impulses and drives. Furthermore, also like the boid-model, an OEE-system, on many accounts, is also often described by using ingredient from an associated biological nomenclature, taking on words such as diversity, complexity, creativity, and novelty, which gesture towards the idea that evolution is essentially a creative force: life, as it were, *wants* to reinvent itself.

To this end, the concept of OEE carries theoretical ties to biologist Stuart Kauffman’s (2007) notion of “adjacent possible theory” - the idea that evolution always pushes into the adjacent possible, into shadow futures hovering on the edges of the present state of things³³. In addition, OEE may also be considered from a philosophical angle by its family resemblance to what philosopher Henri Bergson (1911) termed “Creative Evolution” - a conception of evolution that prioritizes the creation of forms and the continual elaboration of the “absolutely new” through “invention” (Bergson 1911:11). With the notion of evolution as essentially a creative force, Bergson proposed to steer a course beyond the opposition of mechanism (associated with neo-Darwinism) and finalism (associated with neo-Lamarckism) to see evolution as something operating between determinacy and indeterminacy. In short, Bergson proposed a philosophy that accounted both for the continuity of all living things and for the discontinuity implied in the evolutionary quality of creation itself. Creativity is at the core of OEE, as something always-already overcoming itself, becoming something new, without ever settling into an equilibrium state³⁴.

³³ I will return to this concept later on, as it is also central to how the lab members see their work to be about pushing into the yet-to-be-known, into “adjacent possibles”.

³⁴ Meanwhile, however, there is no consensus on any precise definition of OEE, and a true understanding of OEE, as some of the lab members told me, is still “a holy grail in ALife”. When I became introduced to the concept of OEE by the lab members, and when I later began to read about it, it quickly became readily apparent how a slew of scientists across various fields such as artificial life, artificial intelligence, machine learning, biology, physics, computer science, information science, and complex systems science, winkled and pried to pin down some essential definition of it. More recently,

Lana is one of the lab members, who have taken upon her to construct a full-fledged model of OEE, meaning, in the words of Lana, to build “a living world that is forever interesting”, a world that keeps evolving, and does so in creative and surprising ways. The lab members, on their account, are thereby also variously weighing in on questions waging not only on how to properly understand OEE, how to measure it, but also how to actually construct it. However, the “dream”, as Lana notes, to construct an OEE-system, is not something easily realized, no simple task, since efforts to construct a full-fledged OEE-system have over the years proven obstinately resistant to even the most skillful of programmers. As Lana notes, “I’d really like to find out why Open-Ended Evolution doesn’t work, because I think it’s possible, and I think we’re missing something very important, and I’d like to find that!”

Lana’s phrasing of the problem here, during fieldwork, struck me as an odd one, positing OEE as intrinsically *dysfunctional*: what is *missing* from OEE, some variable, component or element? How is OEE dysfunctional? And what sort of puzzlement is this: epistemological, ontological, normative, ethical? OEE is dysfunctional to whom, to what? Dysfunctional by what metric, by what property? Of course, what Lana meant when by this was that no model so far had succeeded in fulfilling the criteria for what counts as a OEE-system. And Lana, as I will now try to show, is one of the few lab members, who have explicitly taken upon her to model a full-fledged OEE-system. Yet, she is not the first to do so.

First Batch: Tierra

In the early days of artificial life, in the 1990s, artificial life researcher Tom Ray had already, to go back to Julien’s phrasing, begun to “get at” the problem of OEE when he developed his own model named *Tierra*. Tierra is a virtual system, in which

beginning in 2015, a series of artificial life workshops have been dedicated to OEE, for example, such as the OEE1, OEE2 and OEE3. The latest of these workshops aimed at addressing and discussing key issues related to OEE, such as, “behavioral hallmarks of systems undergoing OEE” and “empirical demonstrations of hallmarks or requirements of OEE in models or natural systems.” Others have suggested that it makes more sense to talk about so-called “evolved open-endedness”, called EOE, a term calling attention to the idea that open-endedness is a consequence of evolution itself, not the other way around.

assembly language programs lodged in random access memory (RAM) self-replicate based on the basis of how efficiently they make use of central processing unit (CPU) time and memory space. As such, according to the system's creator Tom Ray, Tierra is not simply a model of evolution, but an instantiation of it (Ray 1994). In 1992, for example, he wrote about Tierra, "I will consider a system to be living if it is self-replicating, and capable of open-ended evolution" (Ray 1992:372), building such a statement on the functionalist idea that organic life is basically utilizing energy, mostly derived from the sun, to organize matter. In analogy to organic life, then, Ray further wrote that, "digital life can be viewed as using CPU (central processing unit) time, to organize memory" (Ray 1992:373), which points us to the idea that organic life and computer life, according Ray, may share fundamental affinities.

With Tierra, Ray (similar to many of the lab members at the Ikegami Lab) proposed that life is something existing in a logical and informational, and not necessarily material, universe, in which life can basically be considered a process of information replication. In other words, with Tierra, Ray made the assumption that if organic life evolves through processes of natural selection – i.e. as individuals or organisms competing for resources (light, food, space, etc.) such that the genotypes that leave the most descendants would increase in frequency - so too, may digital life, in parallel, evolve through a similar process, but as replicating algorithms that compete for CPU time and memory space. The digital "organisms" in Tierra, in analogy to biological organisms, Ray proposed, evolve strategies to exploit one another in a game of survival, thus mimicking the essential principles of Darwinian evolution. On this account, the digital critters in Tierra self-replicate and evolve "freely" in a somewhat "open-ended" fashion, however without the guidance of an explicit "fitness function".

Such ways of describing Tierra, as science scholar Katherine Hayles (1996) notes in her article *Narratives of Artificial Life*, are clearly flecked with biological language, including references to Darwinian evolution, natural selection, mother and daughter cells, parasites and ancestors (Hayles 1996). As Hayles specifically takes note of in Tierra, "Ray's biomorphic namings and interpretations function not so much as an overlay [...] as an explication of an intention that was there at the beginning. Analogy is not incidental or belated but central to the program's artefactual design" (Hayles 1996:150), to which she appends that "the program operates as much within the

imagination as it does within the computer” (Hayles 1996:147). Similarly, as anthropologist Stefan Helmreich (1998) shows, computational worlds such as Tierra forms the substrate for computational life, that is, life as an informational pattern, or pure form that is independent of its material substrate. Systems like this, Helmreich further notes, exemplifies the “implosion” of embodied complexities of living organisms onto the cleanliness of the purely formal genome that favors disembodied rationality over embodied materiality (Helmreich 1998). As such, while Ray asserted his claim that digital life is analogous to biological life, that is, digital life operates according to the same principles as biological life, it aligns well with how the lab members at the Ikegami Lab describe their own systems. However, the lab members at the Ikegami Lab do not conflate life artificial and life biological as such, but they are equally invested, as Hayles notes, in making programs that operate as much within their imaginations as in the computer, as we shall see in a bit.

One of the fundamental problems of Tierra in “achieving OEE”, Lana also makes me aware of, is that each particular run of the system will eventually reach a state of equilibrium, or a kind of stasis, where only neutral variations emerge. That is, Ray’s Tierra-simulation basically fails at fulfilling the principles of OEE because it ends up leaving no space for further replication³⁵ *beyond* the point of equilibrium. And such tendencies, Lana tells me, are generally widespread in artificial life simulations, whose digital “worlds” initially tend to evolve very rapidly only to reach an equilibrium, or, as Lana further notes, “a state where nothing interesting happens.” Furthermore, another major problem of earlier attempts to construct a successful OEE-system, Lana continues, is that each “species”, like Tierra’s digital critters, which are defined by the creator, for example as “species A” or “species B”, stop replicating when reaching a specific “fitness value”. However, a notable difference between Tierra and other models of evolutionary computation, such as GA’s, is that there is no explicit “exogenous” fitness function for the interacting agents. Rather, in

³⁵ As a side note, though, in order to overcome this problem, Ray introduced a program that he called “the reaper”, a program “killing” off the digital creatures of Tierra once memory had been filled to some specific level, say 80%. The reaper then selected and killed the “oldest” creatures deallocating their memory (Helmreich 1998:111). Such a control mechanism supposedly “equalizes” the system such that a sort of continuation is ensured. However, the point is that such a control mechanism is exerted from the “outside”, by the creator of the system, and not an internal mechanism to the system itself. Open-Ended Evolution, in its purest form, should be able to self-differentiate and by itself create novelty.

the case of Tierra, the fitness function is “endogenous”³⁶, which means that there is simply survival and death.

However, one of the oldest and probably the most popular explanations for why systems like Tierra failed at achieving OEE, Lana explains, is the one saying that simulated worlds are simply not “complex enough”. In other words, simulated worlds do not adequately correspond to real world complexity, where, as Lana says, “one would see millions of species interacting with each other, competing, collaborating, forcing life out any long-term equilibrium”, thereby suggesting to critics that building an extremely complex simulation with millions of computers would be key to increase complexity to a level corresponding to real world complexity. In short, the problem has to do with lack of computational power. Moreover, according to Lana, the issue is not a question of unbounded complexity, of reaching a certain level of complexity as such, nor about the lack of any consensus about how “complexity” should be defined. Rather, the problem is about creating, she asserts, unbounded “novelty”, to which she believes that we should focus instead on questions such as, “how did evolution ‘invent’ new things or push organisms to reinvent themselves and their surroundings?” On this note, then, Lana identifies two central problems in getting at OEE: the problem of the “environment” and the problem of “fitness”.

Achieving Open-Ended-Evolution, In Theory

“In many simulations” Lana explains, “you have a species of interest, for example like wolves and sheep, and around those you have ‘the environment’”. The first problem relating to the “environment”, defined as the three-dimensional virtual space in which such “species” vie to survive and reproduce, is that such a space *itself* is usually not subject to evolutionary pressure. This means, according to Lana, that the environment cannot be modified or manipulated by the species themselves, only the species are subject to evolutionary pressure, nor do they possess the power to alter

³⁶ To specify this a bit: in Tierra, the “fitness” of an agent, and the rate at which a population turns over, is “endogenous”, which means that it emerges from many actions and interactions over the course of an agent’s lifetime. This is an important point to the work of evolutionary computation that agents need to evolve and replicate “autonomously”.

their world. And Lana is, needless to say, puzzled by this because, she says, “in real life, ‘the environment’ is constituted by other organisms who also undergo evolution, and of non-biological features that can be affected and can affect the organisms around it”. In short, the organism-world relationship, which Lana here opposes, is a one-way street. Such interactions, Lana thinks, should apply equally to their models.

That said, Lana’s second problem relating to “fitness” - a measure of how well “adapted” individual organisms or species are to their environment – is further related to her first problem of “agents” living in a fixed and unmalleable environment. But “fitness” specifically has to do with how simulations are typically designed, as Lana takes note, “in virtual worlds, evolution means that the fittest individuals will have more chance to reproduce than other less fit individuals. More often than not, it means that the species will reach an optimal, stable value of fitness, at which it stops evolving, or that fitness will oscillate around a constant value.” In other words, “fit” species will outcompete the less fit species, and in the process, win the game of survival, coming out on top with no “opponents”, “enemies” or “antagonists” over which to assert themselves. Following from this, each individual agent of a single species or group will stabilize and oscillate at a constant value, which means that they will become somewhat dormant with nothing more to do in their solipsistic world. Lana summarizes the second problem as it relates to the first, “I think it could be interesting to run a simulation where the environment would be subjected to evolutionary pressure, and where long term optimal fitness would not be reachable.”

In theory, then, OEE can be achieved, Lana preemptively proposes, for example, by adjusting a fitness value of a digital organism as an extremely localized property, both in time and in space, making way for creating new niche environments. As such, “inter-individual interactions”, Lana says, “would prevent any good global solution to the problem of survival”, in the process making the model more “nuanced” and “original” in the sense of offering fidelity to how things work in “real life”. That is, rather than having individuals from one group fighting off against another group of individuals in order to survive, they would rather “mate” to produce offspring, which Lana prefers categorizing as “mutants”.

In doing so, Lana makes the claim not to predefine “species”, but rather allow “speciation” to happen in situ. Evolution, then, should be “biased”, as she notes, to

generate “mutants” from new species that are “fitter” than mutants from “old” species without, she concludes, “any reference to complexity”. Finally, if speciation can be achieved, it will potentially ensure that the model will, in Lana’s words, “never get stuck”, and that “evolution should focus on affecting a net of inter-species interactions and the properties they rely on”. As Lana reassures me, this is not simply “theory-talking”, so she had launched into proving her hypothesis by building her own model.

The Model: A World That is Forever Interesting

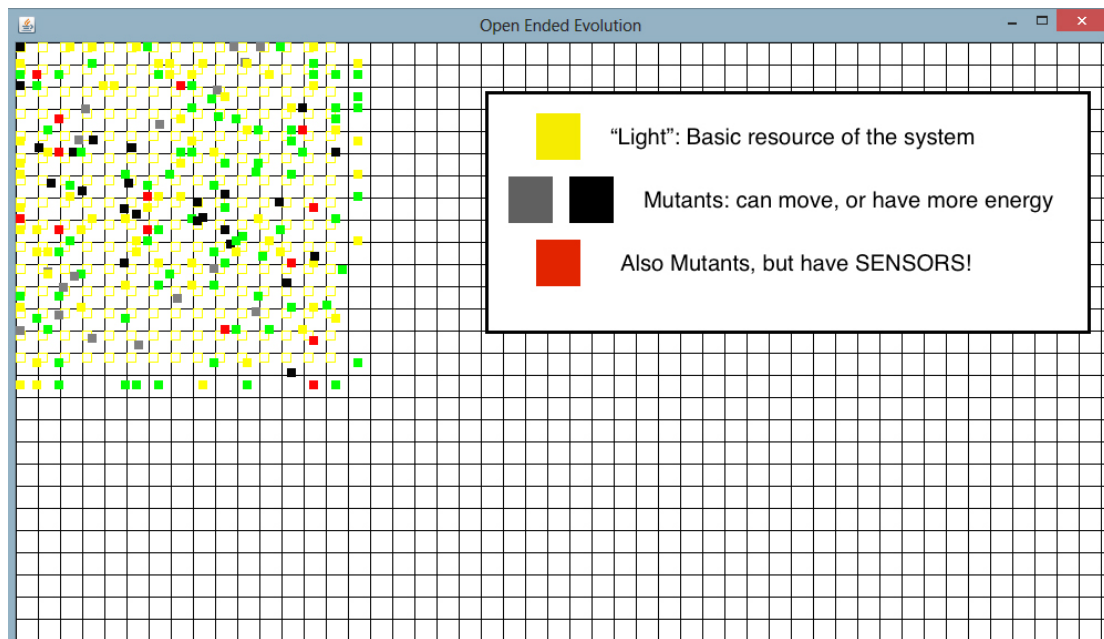
In her own research, Lana have for long been curious to figure out how to program a machine capable of adjusting its cognitive complexity to the environment, so that prediction emerges from action and classification emerges from prediction. “Action, Prediction, Classification by order of importance,” she says, “these are the functions an organism needs to use a complex environment to its advantage, and this is what happens in the real world.” To better understand this, i.e. how organisms adapt, cognitively, to the environment, Lana had made several models. In her current effort, however, to construct her own OEE-system, she had “stumbled” upon a paper by cognitive psychologist Donald D. Hoffman (2009).

In the paper, Hoffman argues against three common assumptions about how human perception works. The first assumption is that the goal of perception is to estimate “true” properties of the world, the second assumption that the goal of categorization is to classify structure, and third and final assumption that aeons of evolution have shaped human senses to this end (Hoffman 2009). On “evolutionary grounds”, Hoffman argues, all three assumptions are false. Rather, as Hoffman states, “our perceptions constitute a species-specific user interface that guides behavior in a niche. Just as the icons of a PC’s interface hides the complexity of the computer, so our perceptions usefully hide the complexity of the world, and guide adaptive behavior.” (Hoffman 2009:1).

Linking to her own interests, Hoffman’s proposal to offer a new “interface theory of perception”, Lana surmises that the following statements were also false: 1) that the

goal of perception is to estimate “true” properties of world, and 2) that evolution has supposedly shaped our sense to reach this goal. In accordance with Hoffman, then, the goal of perception, if there ever was one, is to “simplify the world” and that evolution will “favor” fitness over exactitude (Hoffman 2009). To this end, Lana reckons that there is a strong link between Hoffman’s claims and OEE, as a process not necessarily seeking optimization, but rather seeking novelty and newness. This includes for Lana the idea that fitness functions depend not simply on one factor, but on numerous factors, such as the “cost” of classification errors, the time and energy required to compute a category, and the specific properties of predators, prey and mates in a particular niche. In other words, Hoffman offers to Lana a more original, and indeed “realistic” take upon how “real” organisms adapt, cognitively at least, to their environment, an environment whose qualities and properties are not immediately available to the agent. The point being here that the lab members seek not only to build new models, but to build theories and concepts into them to better understand them.

Thus, Lana had set about to design a model, partly based on Hoffman’s arguments, in which digital agents, (the “mutants”), do not have direct, perceptual, access, she notes, “to the exact, direct identity of others”, what she refers to, following Hoffman, as a “perceptual interface”. Equipping her mutants, then, with a perceptual interface, she claims, makes them “simplify” the world as “we do”, not to mistake it with fidelity. If one mutant, on the contrary, is to mistake the world for fidelity, as Lana warns me, it could “lead to terrible errors”. This is a major point in her nascent OEE-system. Showing me a screenshot of her own first batch, she further warns me, “Beware! I absolutely do not care about the realism of the simulated world: light is born, and dies, reproduces and turn into animals,” making sure that I will not confuse it with reality. This allusion to “realism”, Lana affirms, means that I should not take her model as a full realization of the principles of OEE, but rather treat it as a sort of prototype, which contains things that do not correspond to how things work in the real world. As such, Lana is not, like Ikegami and Olaf are doing with their boid-model, pushing this model into an isomorphic relation as a such, but rather using it to explore what she associates with the concept of OEE, which is imagined to correspond to how evolution really works.



Lana narrates the screenshot above showing a part of her model,

So, you have an artificial world with individuals that we hope will evolve into something interesting through interactions with each other. The yellow individuals are how we input free energy in the system. It means that they appear every few steps, 'out of nothing'. They cannot move, or eat, or do anything interesting really. They just contain energy, and when the energy is used up, they die. I call it 'light'. Then you have the mutants, which appear on the field like light, but with a random twist [grey and black individuals]. Maybe they can move, or hypothetically store more energy. Mutants can produce one or more kids if they reach a given energy threshold, so they do not need a mate in order to reproduce. The kid can in turn become a copy of their parents, or, mutants of mutants. Finally, you have the interesting mutants [red individuals]. These have sensors: if something has properties that their sensors can detect, they eat it, or try to eat it. Eating is the only way to store more energy, which can then be used to move, or have kids, or just not die, so that's pretty important!

In Lana's digital world, as shown on her screenshot, individuals do not have access to the exact "identity" – i.e. the amount of stored energy – of other individuals. Lana continues, "it sounds a bit like the real world, no?" as she appends, when she provides yet another example of how this is so, "you can say that buffaloes that move slowly are maybe not very energetic, so as a lion, you should try to eat them. But there is no guarantee that you will actually be able to overpower them, right?" Thus, each individual, in other words and to go back to her reference to Hoffman, has a "perceptual interface", which "simplifies the world while not representing it with fidelity". Or more precisely, what Lana is saying is that each mutant cannot fully know the properties, nor the intentions of the other, which in turn may lead to terrible errors that in this case potentially result in their own death: the lion cannot necessarily determine and know about the exact condition of the buffalo. Lana had thus prepared a virtual world with a wider margin of indeterminacy. "If we let this world evolve for long enough," she concluded, "we might see interesting things."

The Quick and the Dead

Running Lana's model, "light" turns into "grass", but with no hardwired definition of "species" is formulated in advance. Rather, speciation happens through interaction: when two individuals, or two mutants, encounter one another, one can never be sure of the other's exact identity, that is, determine the "strength" of the other. However, through their sensors, each individual can estimate certain properties of the other, but must rely, as Lana says, on "heuristics", "slow animals usually have less energy than me," she explains, "therefore I should attack and eat them. Yet, you may well encounter an individual that appears slower than you to save energy for reproduction, but it still has more energy than you, hence you die in your attempt to attack it. Nonetheless, your heuristic, your estimation of the other, must be true most of the time in order for you to survive. The quicker individuals might then misread the slower individuals and thus end up dead."

In most of those simulations Lana already knows about, individuals from, say,

“species A” can easily recognize individuals from its own phylum or from “species B”, that is, know about the exact properties and identities of the other. In other words, A has full knowledge of B and vice versa, as Lana further reports,

In most simulations that I have seen, an individual from species A can recognize any individual from species B or from its own species A with absolute certainty. I suspect that often this is hardcoded inside the program: ‘if x.species = A then ...’ Even if B undergoes a series of mutations increasing its fitness, A might be able to keep up by developing corresponding counter-mutations because there’s no choice. A eats B. If B becomes ‘stronger’, which means more energy storage, only the strongest member of A will survive and reproduce, making the entire group of A stronger. If some members of B become weaker through mutation, they will die.

But how are perceptual interfaces key to Open-Ended-Evolution? As Lana reveals, evolution is not a game of the quick and the dead – becoming faster and stronger is not how one “wins” in evolution. Rather, if one equips an individual with a “perceptual interface” – a treacherous one it seems – “we allow the interplay between individuals or ‘species’ to be much richer and original,” she concludes. If one plays such a scenario with a perceptual interface installed,

A only detects and eats individuals that have a maximum energy storage of X, and usually, these are individuals from species B. If some B mutate to get stronger, as far as A is concerned, they stop being food: they are not recognized as ‘B’. To survive, A might mutate to store more than X energy and detect the new value of energy corresponding to B, but any other mutation is equally likely to help the survival of A, so maybe detecting only lower levels of energy would work if there are weak species around. Maybe exchanging the energy sensor for a speed sensor would help detecting B’s again or any other species. What if B become weaker? As far as A is concerned, B also stops being food because A’s sensors can only detect a certain level of energy. Not only B has several ways to ‘win’ over A, but A also has several ways to survive despite B’s adaptations by adapting to find B again, or by changing its food source.

However, upon finishing her explanation, Lana takes the reservation that one might object that this is not how the “real world” works, saying that “a cat will chase mice, even if they get slower.” Immediately turning this objection on its head, though, she rhetorically asks, “or will they? Quite a lot of animals actually evolved as not to be detected by their predators using tactics involving slow motion, even if it means moving slower in general, like sloths or in specific situation, like playing dead. In simulated worlds, however, going faster or becoming stronger is usually the best way to ‘win’ at evolution.” Now, while such descriptions make the assumption that there is biological, and to some degree behavioral continuity across realms biological and digital, it points to the fact that if this is the case, it can be algorithmically specified.

The claim Lana is allowed to make from her OEE-model is that evolution is not about “winning”, or about becoming faster or stronger, as in Darwinian evolution, but rather, she argues, “despite that we don’t end up with a ‘blob of life’ with individuals spread everywhere, we don’t have a ‘tree of life’ clean and straight like in the textbooks. It’s more of a beautiful mutant broccoli of life, with blobs and branches. And this sim doesn’t even have sexual reproduction in it! That would make the broccoli even cooler.” After having run the “sim”, Lana, she was asking herself, she tells me, “did I build an OEE world? Ok, probably not. But I like it and it lived to my expectations.” Following Hayles once again, an OEE-system resides as much in the imagination as in the computer.

Maker’s Knowledge

At the Ikegami Lab, information is the true *presupposition* of our world in the sense that information is *always-already posited*. That is, as philosopher of science Susan Oyama (2000) would have it, “information ... exists before the interactions in which it appears” (Oyama 2000:27). As such, this underwrites, I think, a structure of feeling among the lab members, a sense that the informational dynamics of life not only presuppose *any* sort of interaction, but also that the informational dynamics of life, i.e. how life is informationally organized, are somehow immortal. Indeed, if information can, in some instances, be pried apart from its material vessels in living and nonliving

entities, with information becoming the basis on which these entities are able to interact, then, as Ikegami notes, “information governs everything.” Here, though, I want to make a sober suggestion and claim that information is posited as a sort of meta-value, some shared quality, upon which the lab members are allowed to speak about life in a pure informatic idiom, an idiom that casts humans, machines, hurricanes, toasters and models on the same epistemological register: as complex dynamic systems, despite their ontological differences.

To go back to Olaf’s reference to the movie *The Matrix*, and my own analogy to Plato’s allegory of the cave, the idea that “life” is knowable according to an informatic idiom, or rather that “life”, or some essential property of it, is animated by information, is perhaps the result of biology’s long process to distill and extract the core of life from what artificial life researchers now see as the flurry of deceiving shadows? To this end, as rhetorician Richard Doyle (1997) argues, life is the, “unseen unity that traversed all the differences and discontinuous of living beings,” becoming the “guarantor of biology, knowable only at a distance” (Doyle 1997:11). Similarly, devoid of material significance, but ascribed ultimate regulative and ordering power of the world, including its inhabitants, humans, machines or otherwise, information is the meta-value underlying life at the Ikegami Lab. In other words, as philosopher Eugene Thacker (2009) sees, life depends on an ontology that can never explicitly stated as such, so that life, Thacker notes, “appears as ontologically empty while it remains politically operative” (Thacker 2009:32). As such, something always, Thacker concludes, “happens” to life, as “that which is already expressed, already operative, already qualified.” (Thacker 2009:33).

Or, to put it even more crudely, and perhaps even unfairly, if information is the “really real”, or the meta-value underlying life, it is perhaps the phlogiston – a substance supposed by 18th-century chemists to exist in all combustible bodies, a substance releasing in combustion (which later appeared as a pseudo-concept betraying their ignorance of how light really travels) – of contemporary technoscience? Nevertheless, information is what animates living and nonliving things for many of these lab members, who share the view that information is the “really real” to the epiphenomenal world we live in, offers a kind of cybernetically-

inflected form of spirituality, one akin to that celebrated by figures such as Ray Kurzweil, who believes that it may be possible to upload human consciousness into long-lived robots (cf. Helmreich 2016:6).

However, the fact that the existence of an “information layer” is “obvious” for artificial life researchers, as Olaf notes, it is so, I suggest, exactly because of the construction of models, as a backdrop for querying the informational patterns or structures of what they associate with living activity. Such an assertion, as rhetorician Richard Doyle (1997) further notes of the “postvital” turn in the twentieth-century, marks the collapse of the body, indeed of the material, onto “a transparent sequence that has nothing behind or beyond it” (Doyle 1997:13). However, while many of the lab members do seem to collapse bodies, living and nonliving, onto information, as the axiomatic basis upon which any interaction may occur, they still pursue a better understanding of the informational dynamics of life exactly by constructing models. Indeed, this confluence of making and knowing, between constructing things to make knowledge claims about the world, is endemic to what I mean by maker’s knowledge - the powerful knowledge that can be forged *only* by constructing, rather than finding, something new.

Now, however, according to Ikegami, they still lack a proper understanding of how to deal with the relationship between “bodies” and “information.” More specifically, as Ikegami observes, while some of the lab members spend most of their time doing computer models, either revamping old ones or making new ones, they also raise a bunch of new questions about the relationship between the “information layer” and what he terms the, “physical layer”, a layer, which is simply the physical world of material bodies, the tangible world of materiality that we live in. Although information, at least to some of the lab members, can be completely pried apart from its material moorings, what keeps puzzling them is how to calibrate life’s informational dynamics to its material forms. This means that while one can speak of information as disembodied, the lab members do not fully recognize that it is so. To them, information might be governing everything, yes, but it is not necessarily disembodied or simply imagined to be “free-floating” outside the realm of materiality (cf. Helmreich 2016).

Thus, in keeping with Ikegami's notion of the existence of a segmented and layered reality, then, he further laments, "even though information governs everything, we still try to understand the relation between the physical layer and the information layer, which is so far not successful," to which he adds the question, "so, for example, if there's one bit in the information layer, and there's some physical structure that supports this one bit ... I mean, if you take information from a DNA molecule and count one bit of DNA that encodes biological structures, how much energy is needed to support it?" What this means is that they lack a proper understanding of how to give body to information, so to speak, that is, how to translate the immortal qualities of information into material entities, so that such qualities might become further available to us and our senses in what Ikegami calls, "the real world".

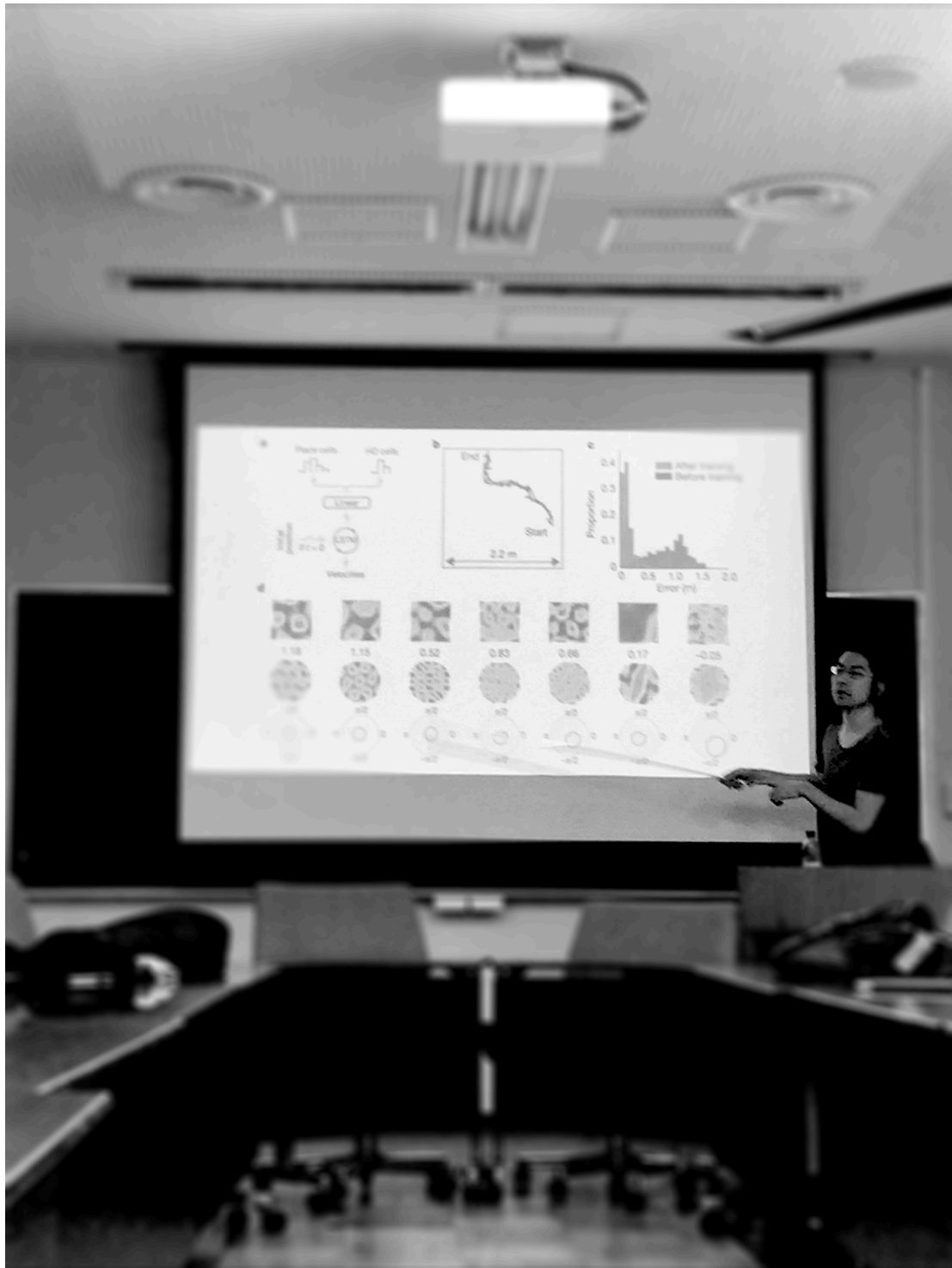
It is to this complex I now turn: the problem of making sense of the relationship between the "information layer" and the "physical layer", and especially what Ikegami means by the "real world". More precisely, in the coming chapter, I examine how Ikegami construes the relationship between the "physical layer" and the "real world" in order to outline how the principles and logics of their informatic vision of vitality are extended and pushed into their understanding of reality itself. What I specifically want to make clear from this is that Ikegami is central to how the lab members see and understand reality itself. Indeed, I want to show how Ikegami becomes the author of an entire ontology, which is "performed" at the Ikegami Lab. And so, in the next chapter, I begin to unpack in more detail Ikegami's nascent ontoepistemological that I call Ikegamianism, which is key to understand how Ikegami seeks to craft a new paradigm in science. That is, to be sure, by articulating *MDF as an ontology*, as I will show in the following chapter, I discern what constitutes the "onto" in the ontoepistemological framework I call Ikegamianism.

4

**THE WORD FOR WORLD IS MASSIVE DATA
FLOWS**



Takashi Ikegami's office door at Komaba Campus, University of Tokyo. Photo courtesy of: author.



Atsushi Masumori updating us on his research at a lab meeting, Komaba Campus, University of Tokyo. Photo courtesy of: author.

Introduction: The World of Massive Data Flows

“We live in the era of massive, massive data flows,” Ikegami tells me one afternoon in his office. “The world,” he continues, “is overflowing with excess data flows and information and this is why we, as scientists, need to change the way we understand the world.” I notice his confidence when he speaks. “But this massiveness is not human,” he continues and pauses, brushing his hand through his dark fuzzy hair, and then continues to explain how this is so. These so-called “massive data flows” resounds what Ikegami means by the so-called “third era”, the era in which the world, following Barabási, who we met in chapter 2, has turned into one big laboratory. However, over the next hour or so, I discover that this “world” of “massive data flows”, which is supposedly rendered visible by the vast, and largely uncontrollable, digital footprints we leave in everyday life, is *not* the fantastic “nonhuman” digital reality we engage with on an everyday basis. Rather, as Ikegami explains, this “world” of “massive data flows” is the “real world”, not simply the digital world, one where all kinds of physical phenomena are emerging through all possible forms of informational exchanges, interactions, and the coming together of heterogeneous elements.

I ask Ikegami to give an example of “massive data flows” and he readily responds, “well, I believe life is transient,” to which he appends that all phenomena, living and nonliving, including human beings, are basically conglomerates of heterogeneous “data flows”. Of course, this vision may come as no surprise, since all the lab members subscribe to the idea that informational dynamics are immortal. However, since Ikegami is equally concerned about the relationship between the so-called “information layer” and the “physical layer”, he here takes the notion of information to a new ontological level. The phenomenon of light, for example, shining off the surface of a wall, in turn making beautiful or strange-looking patterns; vibrations in the air produced by, say, a person’s throat that constitute what we know as language; or ripples on a liquid surface, making diffractive patterns, are all forms of physical phenomena, Ikegami asserts, that emerge and take shape through interactive dynamics, through “data flows”. And among such nonhuman phenomena, human beings, too, Ikegami continues, are “a common phenomenon that emerges out of

massive data flows,” an emergent phenomenon coming into existence as a fragile and precarious being just like anything else. Everything, Ikegami explains, is thereby impermanent and transient, and the so-called, “excess” data flows and information is what slips away and vaporizes, that, which never materializes into, say, solid units, diffractive patterns, human beings, or language, into syntax comprehensible to human ears. But this hyperbole, and what to me seems like a cybernetically-inflected vision of reality, Ikegami concludes, is one saturated, he says, with “too much information”. It is, in a word, a sort of reality somehow constituted not simply *by* information but in a *deluge* of it. But unlike Barabási’s digital reality, Ikegami’s reality is very “real”.

Over the course of fieldwork, and as already noted, I would hear Ikegami and the lab members talk at length about how various phenomena, including human beings, as living phenomena, are basically fragile things. But such fragile things are not simply constituted by information, I learned, by heterogonous flows of information, but they are also seemingly entangled in a deluge of it. There is, in other words, too much information, too many flows, and so reality, or what Ikegami also refers to as the “real world”, is a sort of large-scale, more or less stochastic, complex dynamic system³⁷. And insofar this is the case, Ikegami makes clear to me, we should, “embrace massive data in everyday life,” not only as constitutive of reality, that is, as that which is the basic substance of our world, but also, as he says, because “everyday life provides sufficient complexity and large data flows to conduct an effective analysis”. What the lab members need to do, as scientists, Ikegami suggests, is to learn how to harness and reassemble “information” - bits and pieces, bits and bytes - in new ways to construct new things in order to discover something new. But more importantly, I think, what Ikegami is really doing here is extending the logic of information and a cybernetic vision of reality into an ontological domain in claiming that, “the real world is composed of massive data flows”.

³⁷ Put into the language of the sciences of complexity, such a world is also a dynamical system capable of generating surprising emergent properties. However, more aligned perhaps to Ikegami’s background as a physicist, it also aligns to a quantum physics’ view of reality, one where there is no observable property of any system that in any meaningful sense has a reality extending beyond the mathematical equations that describe it. Yet, as we shall see later in this chapter, and the next, this world is indeed one that escapes the grip of mathematical equations, indeed, scientific formalisms.

During fieldwork, many of my conversations with Ikegami often lapsed into highly abstract territory, and so this idea of “massive data flows”, as the basic ontological unit of reality, may not have come as a surprise. However, the sort of world Ikegami is here enacting, and the sort of world he wants to understand is not simply, as we saw in the previous chapter, “the information layer”, but rather a very “real” world suffused by “massive data flows”, or simply MDF. This world resembles, I think, that of Don DeLillo’s (2009) absurd media-saturated and information-glutted world of *White Noise*³⁸ but is not confined to some virtual or digital domain. And maybe this analogy to DeLillo is not too far off, since the “real world”, according to Ikegami, is flooded with massive data flows to the extent that it creates more noise than signal. And so, this media-saturated “real world” cannot simply be apprehended and comprehended by the logics, tools, and installed systems of representation of what Ikegami refers to as “normal science”, which I will query in the next chapter, nor is this sort of reality simply reducible to, or replicable in, the binary logics of computation, which is why they must change the way they understand the world. The real world, in a word, is at once *more* complex, stochastic, irrational, unpredictable, emergent and transient than any computer program or digital reality is able to capture or replicate, and it is to this real world to which artificial life should be committed.

Thus, if the main goal at the Ikegami Lab is ultimately to “construct” artificial life in the “real world”, as stated as a central ideal to the “third era”, I would be remiss not to ask: what *is* the real world? Particularly, what sort of “real world”, “reality”, or “principle of reality” are these researchers at the Ikegami Lab committed to when wanting to construct artificial life? What is it they seek to construct in the real world and what is the relationship between “construction”, “understanding” and “the real world”? If Ikegami and the lab members insist that they need to change how we understand the world, what sort of world is initially supposed to be understood, and

³⁸ In Don DeLillo’s postmodernist novel, *White Noise*, he comments on the dystopian connotations of late capitalism by pointing to the precariousness of the seemingly safe and idyllic life of small-town North America. However, the security of DeLillo’s consumer society is soon punctured by two disturbing events: an industrial accident leading to the possibility of large-scale toxic contamination, and unlicensed drug experiments meant to cure the fear of death, which eventually lead to violence and death. DeLillo’s fiction combines humor and drama in an absurd world, juxtaposing the false certainties and dreams of white suburban communities and the cynical reality of a thoroughly commodified and TV-saturated reality. Two things especially stand out in analogy to Ikegami’s “world”: that the world has become increasingly suffused by information technologies, in turn saturating it with excessive data, and that much of this world is thus mediated and known through media.

later changed, if not the world of “nature”, nor to its computational doppelgänger, the virtual worlds of computer simulation? To better understand what it means to construct artificial life in the real world, I want to maintain, it is therefore equally important to understand what they mean by the “real world”, particularly what Ikegami means by MDF.

In what follows, then, I want to address how Ikegami envisions and describes the real world, as a space ontologically over-excessive, complex, messy, hybridized, information-driven, and even, as Ikegami tells me, “savage, barbaric, and uncontrollable”. As we saw in the previous chapters, insofar physical phenomena of various types, such as humans, toasters, hurricanes, even markets, ecosystems and galaxies, may be considered to be complex dynamic systems, I here want to show how this line of thought is radically extended and amplified into an ontological domain to produce what I will claim is a culturally-specific *ontology*. Indeed, my claim here is that MDF, while being a concept and a human construction, is also a claim to reality itself. This demands direct comment: my argument is simply that Ikegami’s active extrapolation of reality, his vision of the “real world”, as engulfed in, and flooded by, “massive data flows”, is a direct claim *to* reality, which that MDF is not only a device to make a claim *about* reality, not simply as a descriptor *of* reality, but a direct claim to reality. This means, in short, that what is at stake here *is reality itself*.

Now, once one accepts this, Ikegami’s claim to reality, consolidated in the notion of MDF, I believe, is part of his personal desire to construct his own paradigm. And by extending cybernetic tropes into ontological domains, I think, allows Ikegami not only to *enact* and *perform* an ontology, but also to forward-engineer the contours of a potential paradigm shift. This, too, demands direct comment: following anthropologist Nigel Thrift (2004), I want to discuss how MDF is a first and foremost a culturally-specific *idea* produced at by Ikegami to account for a world, “in which new qualities are being constructed, which are based on assumptions about how time-space can turn up which would have been impossible before, spaces which are naturalistic in the sense that they are probably best presented as fluid forces which have no beginning or end.” (Thrift 2004:583). In this first reading of MDF, it may

simply be seen as is a culturally specific idea, which accounts for how Ikegami is *constructing the qualities* of the real world, as a sort of cybernetic, codified and datafied media-ecology. Such an “ecology” is not reducible to categories such as “nature” and “culture”, the “natural” and the “artificial”, and hence, with Thrift, MDF may be seen as a sort third term better equipped to account for reality.

But, I want to take this claim a step further, and suggest that MDF is *more* than a culturally specific idea exactly by being a direct claim *to* reality. As such, I want to stretch my argument and treat Ikegami’s claim literally to propose that Ikegami and the lab members are in fact *enacting*, following anthropologist Mario Blaser (2009), an “ontology” of the world, whose very substance is massive data flows. The “real world”, as Ikegami claims, is basically a large-scale, non-linear and dynamic complex system, a sort of “figured materiality” (cf. Verran 2001), of “flow forms which strive for observation and projection” (Thrift 2004:590). And to this end, “ontologies”, such as the ontology of MDF, can be “enacted” and “performed” by concrete practices and interactions, as Blaser also notes, which means that ontologies do not precede themselves, but are rather performed in discourse and in practice (Blaser 2009:3). Thus, my claim is that MDF, as a claim to reality, applies pressure to already established biological understandings of “nature”, but it also becomes a device of “world-making”³⁹ (cf. Stengers 2018) exactly by virtue of calling attention to, or indeed calling out, an ontology, which is not only saturated by information but flooded by it.

Performing an ontology of MDF, I argue, is the first step of Ikegami’s plan and desire to construct and establish his own paradigm. What I mean by being the first step is that building, or rather “performing”, and ontology is expressive of what Ikegami’s flaming ambition to somehow offer new ways seeing and attending to the world. But it is also expressive of his role at the lab, as a central figure, who is able to provide ontological guidance to his lab members by inviting them to see reality as massive

³⁹ The notions of “Gaia” and “Chthulucene”, for example, are concerned with world-making in the way they capture, or attempt to capture, divergent and overlapping activities, often unintentional, many of which exist irrespective of human control (Tsing 2015a; Tsing 2015b).

data flows⁴⁰. Finally, as it will later become apparent, this ontology is the first step in a larger plan to construct, I will argue, a new “ontoepistemological framework” (cf. Barad 2007), by which Ikegami offers guidance to his lab members. For now, though, this chapter concerns the ontological part of Ikegami’s ontoepistemological framework.

The subtitle of this chapter – *The Word for World Is Massive Data Flows* – is therefore a recoded play on Stefan Helmreich’s (1998) chapter *The Word for World Is Computer*⁴¹ in his ethnography *Silicon Second Nature*, in which he shows how many of the early artificial life scientists at the SFI were convinced that “computers are literally alternative worlds” or “alternative universes” (Helmreich 1998:65). Thus, if early artificial life scientists, according to Helmreich, understood computers to be ontologically on par with “nature”, as self-consistent, complete, and closed systems governed by low-level rules that support higher-level phenomena, seeing them as machines operating much like “nature”, then Ikegami and his lab members understand computers to be ontologically discontinuous with “reality”. As such, computer simulations may be “worlds” in themselves, but they do not correspond to, or align themselves with, the complexity of the real world. And once one accepts that MDF is not simply a reasonable model *of* reality, but also indeed synonymous with reality itself, it makes sense to say that Ikegami and the lab members aspire to the assertive claim that the world *is* massive data flows. Allow me to begin by sketching how the lab members talk about the “real world” and how Ikegami defines “massive data flows”, MDF, and how they construe the relationship between MDF and the real world.

⁴⁰ Meanwhile, one may equally question the novelty in Ikegami’s ontology. Is he not simply replicating a quantum physics’ view of reality, simulating a cybernetic vision of reality, or is he simply talking into the hype of his day? Also, one may speculate whether Ikegami is also here applying ideas from one domain onto another. For example, if Social Darwinism is a set of theories that apply biological concepts to sociology, politics and social life, is MDF not similarly applying cybernetic principles and concepts to reality to the point where it conflates with reality?

⁴¹ In his book, the title of the chapter *The Word for World Is Computer* is itself a play on sci-fi author Ursula K. Le Guin’s (1976) *The Word for World is Forest*, a tale about a tribe of forest-dwelling people who use their dreams as a resource for guidance in the waking world (Helmreich 1998:65). However, unlike early artificial life researchers’ claim that computers are ontologically on par with nature, the artificial life researchers at the Ikegami Lab claim the opposite: computers are not worlds but tools with which to explore phenomena “outside” but also “internalized” phenomena such as mind, memory, and more.

Massive Data Flows

On numerous occasions, I overheard lab members speak about the “real world” as opposed to the digital worlds of computer simulations. None of them, as it may already be apparent from the previous chapters, claimed that computer simulations were accurate copies of the real world, but rather that they could spark new questions about life and the living. Moreover, simulations, many of them claimed, often harbored their own internal logics, logics that were preconfigured and determined by their creators, not by “nature” or the “real world”, which also hampered their credibility in terms of being accurate representations of reality. The real world, many of them claim, is on the contrary both uncontrollable and unpredictable, governed by its own logics and dynamics, which cannot easily be replicated within any computer system. While the lab members have different ways of describing the real world, the most protuberant term used for describing reality is, however, “massive data flows”, or simply, MDF, a theoretical term invented for pinning down the uncontrollable, open, stochastic and volatile dynamics of the real world. So, while lab members do talk about the real world, Ikegami is the one consolidating MDF as a shorthand for what they mean by it.

Thus, in its most basic sense, Ikegami defines MDF as such,

MDF is a generic term that identifies a new kind of system dynamics: self-organization in complex open environments. Composed of many interacting heterogeneous elements, MDF systems exhibit self-referential, self-modifying, and self-sustaining dynamics that can enable door-opening innovations. While the Web may be the best example of an MDF system, the concept is generic to natural and artificial systems such as brains, cells, markets and ecosystems.

In this basic definition of MDF, we learn that it is generic in the sense of being highly capacious and plastic, which renders it is sufficiently hazy enough to be applied to just about any kind of system ranging from the slimy organs called brains to the abstract categories called biospheres. As such, an MDF-system may not be any

different, say, from any other complex dynamic system described by the lab members, for example like those we encountered in the previous chapters: anything from economies and ecosystems, as higher-order, although nonlinear and non-equilibrium, systems, may here count as “MDF-systems” with the inherent potential for “emergence”. To this end, this extreme degree of conceptual elasticity recalls many of the ideas we encountered in the previous chapters, in which ideas of complex systems science have been smuggled into the nomenclature of artificial life. Yet, what is here made to make a difference between MDF-systems and complex dynamic systems, according to Ikegami, is that MDF-systems operate in “complex open environments”, i.e. in the “real world”, a site which is profoundly out of control and unpredictable.

In a sharper definition of MDF, though, it is described as a concept, as they say, which, “is the generic term that explains the co-evolution of excess flows,” that, “provides a new methodology for understanding data flows, which includes material, energy and information flows”. MDF is thereby, “analogous to Darwinian evolution and the organization of an ecological system,” in the way, “MDF patterns grow, and this growth determines the organization of a systems’ own state autonomously”. Now, according to this specification, particularly the specifying notion that MDF is *analogues* to Darwinian evolution, does not mean that MDF is opposed to biological evolutionary processes. Rather, it means that MDF is based on principles of Darwinian evolution, which is to say that it works much in the same way.

But some of the lab members also stress that MDF *supersedes* the principles of natural evolution, which means that it in turn becomes “larger” than natural evolution itself exactly by encompassing things that are not normally subsumed by such principles. For example, if natural selection privileges genealogy as the marker of organic species – for example that all life is related and has descended from a common ancestor - MDF privileges, they say, “a bundle of evolutionary paths” that gestures towards the idea that “life emerges in adjacent possible events”, i.e. as a future type that arises not from a single source but from multiple sources. It is, in other words, not necessarily the coming together of biological substances or circumstances from a single “primordial soup”, which is the only path giving rise to life; a bundle of excess flows of data and information may equally give rise to the

living. Stressing that MDF somehow supersedes natural evolution, then, is what supposedly makes it special to many of the lab members, who use the term to deviate from any “normal” understanding of evolution. But as a self-invented concept, the term functions, I think, to mark a specific version of reality, which is explicitly different from other versions that deal with the complexities of evolution, nature, and reality.

Now, before going any further to discuss how the term MDF is applied in their work, this notion that MDF is analogous to Darwinian evolution demands direct comment. I quickly found myself into deep theoretical waters when I learned that MDF was a sort of spin-off from Darwinian evolution, itself a theory of evolution. It seemed, I remember thinking, like an ambitious and bombastic intellectual project to offer an entirely new theory of evolution. Indeed, it struck me that MDF was something like a theory of everything. What do they specifically mean when they say that MDF is “analogous” to Darwinian evolution, and what is “adjacent possible events”? How is MDF different from Darwinian evolution? Why the need to mark this difference?

In its most basic sense, Darwinian evolution, needless to say, is associated with its namesake, the famous naturalist Charles Darwin, who in the mid- to late nineteenth-century speculated that living form materialized out what could be environmental or ecological dynamics, dynamics by which he formulated his theory of evolution by natural selection. All life, Darwin ruminated, is related, and has descended from a common ancestor, and as random mutations occur within the “genetic code” of an organism, only the beneficial mutations are preserved in the service of survival (cf. Darwin in Beer 2000). The beneficial genetic mutations are passed on to the next generation and so on, and over time, accumulating and resulting in an entirely different organism, which may not be considered a variation of the original, but altogether different in *kind*. Thus, for Darwin, the “forms” at stake in his theory of evolution materialize in organic “species” or “organisms”, that is, as durable but changeable genealogical kinds “emerging”, as it were, from evolutionary processes.

Now, if MDF is analogous to these processes, then it means that all living form may equally materialize out of massive, excessive data flows, which in the words of the lab members include “material, energy and information flows”, i.e. *more* than the

biological. This also allows them, I think, to claim, or at least speculate, that life might emerge and take form through processes and dynamics that are not exclusively “natural”, nor organic. However, it is not quite so simple, since MDF does not settle into an equilibrium, nor seeks to optimize from evolutionary processes in the sense that it is only about survival⁴² of the fittest, as canonically coined by Darwin’s countryman, philosopher and biologist Herbert Spencer, but rather it keeps pushing into what the “adjacent possible”. However, before moving on to discuss adjacent possible theory, I will here pause to comment on the idea of continual and random evolution contrary to fixed and determined evolution, which is seemingly inherent to the notion of MDF. In later years, after Darwin first began to consolidate a more thorough idea of natural evolution, he thereby offered an alternative to, “the rationalistic ideal of the complete determination by fixed law of the behavior of each individual particle in the universe” (Wiener 1972:4). In other words, the results of Darwin’s work offered a vision of a world that was open, undetermined, pluralistic, random and individual, a world in which the development of living things was subject to certain environmental processes. Yet, the outcomes of such processes depended, according to Darwin, upon chance, accident and coincidence, as individual variations were fundamentally unpredictable and undirected (cf. Wiener 1972). To this end, MDF and Darwinian evolution are analogous, but they disagree on the what counts as the constituent parts.

The “adjacent possible”, which is also part of MDF, is in its most basic sense associated with theoretical biologist Stuart Kauffman’s⁴³ (2008) notion of “adjacent possible theory”. Adjacent possible theory posits that evolution always pushes into the so-called “adjacent possible”, into shadow futures hovering on the edges of the present state of things (Kauffman 2008). In other words, if Darwin’s “forms” materialize in “species” and “organisms” (that is, settle into concrete things, however, based on contingency and randomness), they may equally, according to Kauffman, also hold an infinite set of possible forms or, in his terminology, an infinite set of

⁴² That is, MDF-systems do not necessarily sustain themselves only because they vie to survive and reproduce, for example, by having the only function to pass on beneficial mutations in the service of survival. More likely, MDF-systems are patterned systems that seek to expand, or become something other than what they were, by adapting to environmental conditions.

⁴³ On a side note, Kauffman was himself associated with the Santa Fe Institute from 1986 to 1997, the years during which the field of artificial life was drawn into coherence by its founder Christopher Langton.

“adjacent possibles”. Living forms, then, may potentially become something other than what they are, always-already holding the potential to become something more, something less, something different, or something new. Kauffman himself claims that biospheres, for example, on average keep expanding into the adjacent possible (Kauffman 2008), that is, that biospheres always push “outwards” to increase the diversity of what can happen next. Yet, if they expand too rapidly, they will destroy their own internal organization, which leads Kauffman to propose that a system, such as the biosphere, complex as it may be, must maintain an internal gating mechanism. The point being that biospheres are essentially too complex to predict, which means that a biosphere’s “configuration space” – the specific set of known variables, laws and forces at play – is in advance unknowable and unpredictable.

Kauffman’s “configuration space”, in turn, may be thought of as Darwin’s “pre-adaptations”, by which a causal consequence of a part of an organism may turn out to be useful in some new, surprising way, a consequence that cannot be predicted in advance. For example, the fact that squirrels have developed useful “wings” from useless “flaps,” or that some molecular mutation in a bacterium suddenly allows it to pick up calcium currents, are instances of the unpredictable qualities of Darwin’s pre-adaptations or Kauffman’s configuration space. In short, such mutations count as instances where morphologies, as it were, push into the adjacent possible – they become something other than what they were. More to the point, Kauffman’s own models, though rigorous, mathematical and dense, posit that adjacent possibles are always-already potential, undetermined, and surprising, always hovering as shadow futures at the edges of the present state of things. Kauffman, however, in contrast to Darwin, has taken this idea to its logical conclusion, noting that adjacent possible theory not only concerns evolution or organic things, but rather *all* kinds of phenomena, including the real world, social processes, society, synthetic substances, and artificial media, things that may equally be mutually entangled and always-already pushing into the adjacent possible. As such, Kauffman’s more ambitious claim holds that an innumerable potentiality for becoming something else is key to the adjacent possible. Yet, still, one cannot posit in advance, nor predict, the outcomes.

Stochasticity, randomness, unpredictability, and indetermination are essential components of MDF-systems that they are considered to be “open” systems, which

means that they always carry the potential for becoming something else (i.e. they are non-equilibrium systems). MDF-systems are generated in complex interactions of material, energy and information flows (thus, they are non-linear systems), and, as Ikegami tells me,

Unlike systems studied in isolation or at equilibrium, MDF-systems are open and driven systems, existing within a rich context, constantly changing, growing, evolving, and thereby autonomously changing the way in which they interact with the environment around them. The patterns that they exhibit are neither imposed from outside, nor arise internally, but are a consequence of the interface between endogenous data flows within the system and exogenous data flows that perturb it.

Now, the point here, following Ikegami, is that MDF-systems do not exist *prior* to their interactions, which means that they “emerge” and “self-organize” from the muddle of massive data flow themselves. As such, as Ikegami concludes, “if ‘Big Data’ systems exhibit volume, velocity, and variety, MDF-systems exhibit vitality.” Notably, Ikegami’s version of Darwinian evolution and its associated theory of the adjacent possible is built and assembled on the basis of prior theories. Yet, MDF is itself, to pun, a *variation* of other more or less similar theories made to mark clear differences from conventional Darwinian ideas about evolution through natural selection. But any attempt to untangle and comprehend any real differences between Darwinian evolution and MDF still seems difficult, as both theories suggest that evolutionary outcomes cannot be predetermined in advance and thereby depend upon chance. This focus on chance and serendipity, though, is exactly what makes it compelling and operative.

When asked to clarify how MDF is different from Darwinian evolution, Ikegami tells me that it is exactly by what it refers to: MDF is not simply “natural evolution”, nor identical to Darwinian evolution, but rather a modified conception of evolution that encompasses more than the “natural”. It is, in the words of Ikegami, “larger” than biological life. MDF, Ikegami asserts, is a single, universal conceptual framework that allow the them to describe dynamic processes of self-organization and self-modifying

capacities inherent to an infinite number of entities – living and nonliving, even languages, cultures, humans and nonhumans – and not simply “organisms” or “species”. Anything, which can be termed “system” in the sense that it is a composite of other things, according to MDF, basically evolve according to the same evolutionary logic. But the point is that evolutionary processes do not only occur in “nature”.

MDF, however, is not so much fully-fledged theory of evolution, but rather itself a rewired variation of Darwin’s evolutionary theory, peppered with more recent scientific insights and concepts provided by scientists such as Stuart Kauffman and Kenneth Stanley (the latter, whose ideas about OEE we saw in chapter 3). While MDF is not a fully consistent theory, it is after all, I think, a social tool that is the difference that makes a difference in the sense that it exposes Ikegami’s desire for inventing new theoretical apparatuses, and ultimately his desire for articulating his own paradigm. That is, MDF, although in many ways resembling established evolutionary principles, is a useful social tool for establishing professional and intellectual boundaries between artificial life and, say, conventional biology, for example, in terms of defining what evolution really *is*. But more importantly, it also expresses, I want to suggest, a desire to be innovative and inventive.

Once one accepts that MDF is a concept that accounts for how various forms of worldly phenomena, and not just natural phenomena, come-into-being through interaction, it can easily be extended, I think, to describe the “real world”. The “real world”, then, is at the Ikegami Lab imagined to be a sort of open-ended, highly precarious, yet unpredictable, system always-already pushing holding the potential for pushing into the adjacent possible with an infinite number of potentialities and probable proclivities. At least in theory. Now, in what follows, I want to show how MDF becomes operative to their work at the lab by examining one particular MDF-system: “The Web”. The Internet, they believe, once again following Barabási, is a site where to explore the dynamics of massive data flows, a site leaving residues of human interaction and sociality.

The Wide World Web

I met Mizuki Oka in a basement café in central Tokyo. Oka, a computer scientist from the Tsukuba University and an external lab member of the Ikegami Lab, wore a sharp pair of steel-rimmed glasses, navy blue chinos and a white shirt⁴⁴. Although employed at Tsukuba University outside Tokyo, she was at the time of my fieldwork engaged in a collaborative research project with Ikegami, a project about “tagging” in web-services. After buying her a cup of coffee, she tells me that once Ikegami introduced her to artificial life a few years back, she “felt like a bachelor student again”. Artificial life was less “rigid”, she tells me, which immediately remedied her ongoing frustrations about computer science, her native discipline. For too long, she continues, she had been frustrated about the uptight ways computer scientists tended to design software systems. “Computer science is a very rigid science. Well, it’s not really a science, and people don’t care about theory, about understanding what’s behind [...]” she goes on, “artificial life cares about that, artificial life is science.”

Over the next hour or so, Oka tells me about the many differences between computer science and artificial life, slowly lapsing into talking about her own collaborative project with Ikegami. “The web ... or the Internet”, she says, “is a perfect example of a complex system,” a term she had been introduced to by Ikegami, “like an ecosystem, the web has its own internal structure and logic. So, Ikegami-san and I wanted to explore that.” The Internet, Oka suggests, is a complex system, a site for exploring human behavior as good as any other place because it is, in her words, “open” to external perturbations and interventions, a criterion for real world activity. A few years prior to my arrival in Japan, she and Ikegami had agreed to do a project on “tagging” dynamics and behaviors online, seeing, for example, social media platforms as complex, yet open complex systems, which are self-referential, self-modifying, and self-sustaining.

⁴⁴ Mizuki Oka is one of the close collaborators of the Ikegami Lab whom I had the pleasure to meet in person. Besides working on projects with Ikegami, she is employed as an assistant professor at Tsukuba University, one of the oldest universities in Japan. Oka is rarely, however, at the lab, and have no other formal affiliation than being an “external member”.

Oka's symbolic association between the Internet and ecosystems - with the word "ecosystem" conventionally meant to describe a community of living organisms in conjunction with the nonliving components of their environment - is also commonplace among other lab members. Indeed, Oka, like many other lab members, does not shy away from using biological concepts and metaphors to describe technical or non-natural systems, for example, such as the Internet. Like an ecosystem, the endogenous structure of the Internet itself, Oka further tells me, is being continuously reorganized upon being perturbed by exogenous flows. To her, it is evident that our era of mass media and the proliferation of the Internet, she says, "carries" so much information that we, as humans, are unable to keep pace, i.e. unable to make full meaning of all the information around us. Thus, "the Internet-system", Oka reports, "consists of a massive number of computers and signal transmission cables, such that each composite computer is a purposeful unit that receives and sends information to other computers". Seeing the Internet system, then, as a "real world" instantiation of an MDF-system (not a complex dynamic system), Oka further suggests that it can itself be considered as a large-scale "homeostatic" device, operating like some sort of living "super-organism", transferring and exchanging information at an incomprehensible rate. In other words, according to Oka, it makes perfect sense describing such a system as a sort of "living" system or an "MDF-system" since it performs analogously to, say, an ecosystem.

Ikegami, too, notes that "though the Internet changes quickly, it preserves a certain structure over time. But at the same time, new pages are constantly being created, either by people or by automated bots. [...] the Internet is capable of constantly exchanging data by adapting to environmental changes. This 'ecosystem' of the Internet has been established over the past several decades". Ikegami and Oka's explicit analogy, linking "the Internet" to "ecosystems", as historian of science Lily Kay (2000) has noted, is not only striking but also indicative of the prevalence of computational metaphors for things biotic, which were ported into biology from linguistics and information sciences during the 1940s and 1950s (Kay 2000). Here,

however, as Ikegami and Oka reveal, they are now ported back from biology to the information sciences⁴⁵.

Now, if the word “ecosystem”, according to Oka and Ikegami, is a metaphor for how the Internet works, it presumes commensurability between both human and nonhuman agents, or “users”, in terms of organization. MDF-systems, in other words, are organized by organization, organization builds organization. But if the word “ecosystem” applies to the “Internet-system”, construed as an “MDF-system”, that is, if these systems are qualitatively identical, it ceases to be a metaphor; they become ontologically synonymous with one another, and only then does it make sense to claim that we are indeed engulfed in “massive data flows”. And rightly so, as Ikegami claims, “the Web is a candidate for lifelike phenomena, in which services that run on the Web must deal with massive data flows, where the underlying structure and the overlying information flow changes constantly.” Social networking services, such as Twitter, LINE or Facebook, for example, as Ikegami elaborates, are nowadays major sources for generating web dynamics that might be similar to the dynamics of nervous systems or ecosystems. “Such spatially and temporally extended web space”, Ikegami tells me, “can be used as a metaphor for living states or conscious states, as the Web picks up the unconscious state of collective human behaviors, for example, recommendations of products or advertisements based on the user’s collective behavior.” And so, Ikegami and Oka are not subtle about the idea that the Internet works much like a super-organism, rather, they are quite explicit about it, as Ikegami reports,

The Web is perhaps the most complex system that we know of. Its massive scale, complex dynamism, open richness, and social character mean that it may more profitable to study using tools and concepts appropriate for understanding nervous systems, organisms, ecosystems and society, rather than approaches more traditionally employed to engineer technology. Simultaneously, scientists, like us, who try to

⁴⁵ For an elaborate account of how physics and information theory have influenced molecular biology in the mid-twentieth century, read Lily Kay’s *Who Wrote the Book of Life?: A History of the Genetic Code*, in which she notes, for example, that the “language of life” is a metaphor infused with “operational force” that was made literal and given scientific legitimacy by linguistics only in the 1950s and 1960s (Kay 2000:1).

understand this wide array of complex natural systems may have much to gain by considering the emerging study of the Web.

What is perhaps clear from this assertion is that metaphors, following Lily Kay once again, travel freely between artificial life and biology, between the natural sciences and the information sciences. But while Ikegami and Oka are, however, claiming that the Internet-system *is* an ecosystem, like a sort of super-organism, they are also making an ontological claim, not simply a metaphorical one. Just as the Internet is an entity held together by relations and by interactions, pushing into the adjacent possible, so too is reality a sort of configuration space, by which it always becomes something other than what it was. As MDF patterns grow in order to determine the organization of a systems' own state autonomously, there is nothing preventing Ikegami and Oka claiming that this also applies to how the real world works. Society, like an ecosystem, for example, is equally structured by social relations, constituting a large-scale network, in which individuals may perturb the collective and vice versa, and as such, society, like an ecosystem, may be no different from the Internet. In this sense, it makes perfect sense for Oka and Ikegami to claim that the web is a sort of "model" of social relations, which can be mapped and analyzed.

The Internet-system, like the any real world-system, or indeed a system constituted, as Ikegami notes, in "real world dynamics", in other words, is what emerges or what happens in between endogenous data flows within the system and exogenous data flows that perturb it.

Now, once one accepts that it is reasonable to conflate such phenomena on a qualitative register, this kind of cybernetic thinking, one might say, collapses things into transient flows and flux, processes and transitions, which in turn riffs on the idea that things, such as the Internet or society, rather than being things that exist prior to their interaction, are things that *emerge*. Such postmodernist ideas have been around for quite a while, and besides relating to a slew of ideas concerning "emergence", such ideas may also recall feminist scholar Karen Barad's (2007) notion that entities emerge in, "the mutual constitution of entangled agencies" (Barad 2007:33), what Barad terms, "intra-action". Thus, Barad opposes her term "intra-action" to the

conventional notion of “interaction”, as that which assumes a prior separation between individual agencies that do not precede their intra-action: agencies, or if we follow Nathaniel’s notion of “individuation” from the previous chapter, “emerge through their intra-action” (Barad 2007:33). More to the point, this claim that the Internet is an MDF-system, situated and constituted in the real world, means that its distinct agency and identity, and the features Ikegami and Oka associate with it, such as massive scale, complex dynamism, open richness, social character, etc., are distinct *only* in a relational sense, not in any fixed or absolute sense. The Internet, as well as the real world, then, cannot exist outside the mutual entanglements of massive data flows, without which it they could not exist independently as MDF-systems.

An MDF-system, then, is what forms up - or what is kept *in*-formation *by* information - in a dynamic configuration space, in which human-nonhuman borders are transgressed, as they are reconfigured by endogenous and exogenous data flows. As such, they are systems emerging, as Donna Haraway notes, “only by relation, by engagement in situated, worldly encounters” (Haraway 1994:64) that take place in a socio-technical “apparatus” (Barad 2007). Here, though, this claim, as I have been trying to suggest, is further pushed into a relation of equivalence with reality itself, as a site of massive data flows, in which we, according to Ikegami and Oka, emerge ourselves as MDF-systems. Yet, once this is clear, Ikegami is not shy to further extend this claim to include the “real world”, indeed, to claim that the world is ontologically “too complex”.

The Complexity of the Real World

While not all artificial life researchers at the Ikegami use the concept of MDF, all of them refer to the “real world”, as a space, which is highly complex, although not completely distinct, from the virtual worlds of computer simulations. That is, the real world is not as such ontologically distinct from the virtual worlds in their computers; rather the virtual worlds are simply part of the real world. The real world, the lab members say, is therefore omnipresent, like a cosmos, in which everything is part. Some lab members, however, use MDF and the notion of the real world

interchangeably, but maintain, as we saw in the previous chapter, that *information* is the basic ontological unit common for living and nonliving things. For example, Lana notes that, “artificial life focuses on the body and its interactions with the real world,” suggesting that artificial life systems should be somehow able to act within, and take action upon, a physical world and not just remain couched in the virtual realm of the computer. Ikegami, when not using the term MDF, believes that, “the real world is complex and unpredictable,” a world, “beyond logic, because there’s something beyond logic that living systems use to survive in the world”, which also bolsters the need for focusing on what Ikegami calls, “real world dynamics”. At the core of such claims, still, is that information is that relational substance that ultimately binds and unbinds entities. Putting it this way, there is nothing preventing Ikegami and the lab members to claim that reality is jumble of massive data flows.

All the lab members agree on the baseline distinction that the “real world”, whether glossed in the concept of MDF or not, is an “open-ended world system”, a somewhat entropic space that is essentially highly complex and unpredictable⁴⁶. Such a world, moreover, cannot simply be apprehended by any mechanistic modes of reasoning, which have historically been employed by science. Neither can it be fully understood by the binary logics of computation, nor be observed from a detached point of observation, from a “God’s eye”-perspective. In the real world, Ikegami claims, the rules of causality do not apply. And as he further notes, “in the real world, I’m part of the world, and it is from here we want to describe it, the ‘internal observer’,” an observation that makes sense due to the fact that things basically emerge in massive data flows, including “life”, and the fact that the real world is omnipresent, always-already. “I mean, computers are, of course, part of the world too,” Ikegami continues, “but they have no power to change anything in the real world. Computer-generated monsters will never eat you. Cause and effect can be simulated in computers, not in the real world,” bolstering Lana’s suggestion that artificial life systems need physical bodies to interact with the world. “In the real world,” Ikegami continues, “we should

⁴⁶ This view includes seeing the “real world” as open-ended site containing a certain amount of “free energy” available for entities to “self-organize”, a view that resounds a physics-view of the universe. This view, in turn, is informed by theoretical and quantum physics, which hold that free energy is what entities need at their disposal to self-organize and maintain their organization. Free energy, on this view, is the resource living things compete for.

not try to stop the massive data flows, but recognize that it's there and then make something out of it.”

Ikegami's statement here, I think, also demands direct comment: the complexity of the real world, according to this view, is ontologically discontinuous with the complexity that can be conjured in computational media. However, more importantly, Ikegami is here alluding once again to the sort of maker's knowledge introduced in the previous chapter: that massive data flows are not just constitutive of reality, but so too, something to be harnessed and made use of to produce something new. Yet, one of the reasons as to why computers have no power to change anything in the real world is tied to the lab members' notion of “complexity”, which is here defined as an in-between form of complexity in the sense that it refers to that which is both organized and disorganized. Allow me to pause for a bit in order to explain how Ikegami and the lab members define “complexity”.

Darwinian evolution is an example of organized complexity, Lana tells me, because “it involves components strongly coupled together, producing organized data that cannot be described by using only statistics”, whereas “Brownian motion”⁴⁷, on the contrary, may constitute an example of disorganized complexity, since it refers to data that is produced from many components of the system loosely interacting together. The type of data generated from disorganized complexity looks complex if each point is observed in isolation, but it can be described in a simple way using probability distributions (cf. Weaver 1947). The sort of “complexity” Ikegami refers to is both (organized and disorganized), which is perhaps best shored up by mathematician James P. Crutchfield (1989), who defines complexity as a mixture of two types of simple systems: random systems, which look complex but are statistically simple, and periodic systems, which are simple to predict. Systems between these two extremes qualify, according to Crutchfield (and Ikegami), as “complex” (cf. Crutchfield & Young 1989). This view of complexity, then, in the words of Ikegami, essentially renders computers unable to capture both modes of complexity, either in terms of lack

⁴⁷ Brownian motion, or *pedesis*, named after the botanist Robert Brown in 1827, refers to the random motion of particles suspended in a fluid – liquid or gas – resulting from their collision with the fast-moving molecules on the fluid. The patterns generated in Brownian motion are formed from random fluctuations in a particle's position inside a fluid sub-domain with relocation to another sub-domain. Each relocation is then followed by more fluctuations within the new closed volume.

of computational power or because computer simulations are too tightly controlled by the experimenter, i.e. only able to reach a tightly controlled form of complexity. The real world, according to this logic then, may be said to emerge in, and consist of, a mixture of organized and disorganized forms of complexity, never completely predictable and knowable, but always able to push into the adjacent possible.

What Ikegami and the lab members refer to as the, “complexity of the real world”, is a sort of complexity, between disorganized and organized, that exceeds the levels of complexity one can fabricate within computational media. This is why the real world, as Ikegami says, “provides sufficient complexity and large data flows to conduct an effective analysis.” But this also means, Ikegami tells me, that “the real world is basically unpredictable, as he offers a sober down-to-earth example,

[in the real world] there are people with autism, there are criminal people, and so on, so what is typical human behavior? It’s quite difficult to define, right? Maybe the common denominator is that we use the same chemical and cellular systems, chemical components and architectures, things that we, humans, share with each other. That’s basically the only thing that we share, but also culture ... There’s something that we share with each other. I mean, there are some things, like cells and culture that humankind share. However, if you’re trying to detect whether this guy is a ‘typical’ human then we’re faced with some difficulties, so there’s no proper definition of what’s ‘human’ or what’s ‘humankind’. That’s what I call life, you know, in the real world. What we miss in a computer is a sense of ‘being there’; life is essentially scary, right? Uncontrollable, barbaric, savage. Life is not simulated, it’s lived.

In fact, during many of my conversations with Ikegami during fieldwork, he variously alluded to this conception of reality, as a “lived” reality in the sense that it is first and foremost experiential and subjective. To this end, Ikegami claims that, “life is not simulated, it’s lived”, a view, one might say already, that runs somewhat contrary to

what any hard-nosed, natural scientist is willing to admit⁴⁸. But this is not to say that the real world is any less complex.

Indeed, Ikegami's view of a lived and experientially available reality, in which the rules of causality are inoperative, bespeaks, I think, what sociologist Andrew Pickering (2010) calls an "ontology of unknowability" – a sort of nonmodern view of reality that is set to reveal, rather than enframe, a world of "becomings" playing out in an "ontological theater" (Pickering 2010:51)⁴⁹. However, if life is "lived" rather than "simulated", it is not quite "theater", but rather something very "real", carried (not acted or played) out in the "real world". Lived life happens, in other words, outside the digital domain of the computer and outside the limited confines of the laboratory. Yet, this real world, is not, it seems, completely unknowable, as Ikegami himself seems to have plenty of hermeneutic tools at his disposal to discern it, for one, MDF. Nonetheless, this lived reality is also, it seems, relentless and even uncivilized, simultaneously very "human" and something "more-than-human". But ultimately, it is a reality that cannot easily be captured by the simulations of computation, ones and zeroes, nor simply apprehended in mechanistic terms of cause and effect.

This seeming incompatibility between the level of complexity of the real world, compared to the level of complexity constructible in a simulated double (in computer simulations) is perhaps best highlighted in Ikegami's own words, "complexity is something that is higher in the real world compared to a computer world. The real world is messy. The complexity of the real world is so messy that we cannot expect there's a simple law that can explain what is going on in the world. Computers can

⁴⁸ I will come back to this point later on in the next chapter, which is about how the artificial life researchers at the Ikegami Lab attempt to formulate a new "nonmodern" epistemology for their field.

⁴⁹ Pickering, like Ikegami, draws heavily on the work early cybernetics of the 1950s to describe how cybernetic systems, such as the homeostat – an electromechanical device created by cyberneticist Ross Ashby, first imagined in 1941, yet finally constructed and realized as a "real machine" in 1948. The homeostat became a new way to explore the workings of the adaptive brain, as a machine consisting of a coil that magnetically moved a needle, whose movement would vary the current to the coil. By doing so, the homeostat would randomly reorganize itself to find a condition of dynamic equilibrium with its environment, regardless of its starting point and any external intervention (Pickering 2010:105). Such a cybernetic system would, Pickering shows, not depend on the amount of energy flowing through it, but on how the variation of energy induces variations in connected systems, like the environment. Key to this line of thinking was that these processes could not be understood as causal relations, but rather as feedback loops between different systems. Thereby, Pickering argues, the homeostat was not only essentially "unknowable", but also became "ontological theater – as variously conjuring up and playing out an ontological vision of performance and unknowability" (Pickering 2010:51).

generate very high levels of complexity, but this complexity is different from what you see in the real world. And part of the messiness in the real world is something that may kill you, eat you, and things like that. You're always entangled in it." Here, Ikegami asserts that the real world is a harsh environment, where one risks death and consumption. Although Ikegami sees a violent world, nonetheless, he insists that we accept that the real world is basically unknowable, which does not necessarily mean that we cannot make something of it.

However, before jumping ahead to discuss how MDF becomes a culturally-specific *ontology*, I want to go back a bit to discuss how the notion of MDF is first and foremost a culturally-certified idea, which becomes a sort "third term" conjured to account *for* a reality before.

Third Term

The notion of MDF, I believe, begs the double question of what it explains and how to explain it. Thus, as already highlighted so far, MDF offers a condensed, albeit metaphorical, vision of reality, accounting for the heterogeneous and often surprising links between bodies and information, scales and levels of complexity. As such, it comes close to being a metaphorical device with which to shore up what Ikegami and the lab members *associate* with reality. Now, agreeing with anthropologist Stefan Helmreich (2009) that theories are tools for explaining worlds and phenomena in the world to be examined (Helmreich 2009:23), I believe it makes sense asking what MDF seeks to explain but also that it is something needs to be explained itself. On the one hand, then, if MDF is simply a theory in the sense that it is a rhetorical device that can be used to bolster, authorize, and/or legitimize linkages and relations between different worldly phenomena, or to animate certain practices to reorient inquiries of life accordingly, it is, I think, vividly expressive of a culturally-specific *worldview*. On the other hand, if MDF is an ontological category, which I believe it is since Ikegami and the lab members use it to make a direct claim to reality (even though it is iffy and slippery), it not only harnesses a highly-dynamic, interrelated and material-semiotic reality, which is not seemingly concomitant with "nature", but rather,

concomitant with something akin to a sort of “second nature”, “after nature”, or “new nature” (Strathern 1992; Helmreich 1998). On this view, then, MDF is also, I will claim, a culturally-specific *ontology*.

Insofar MDF is meant to be a theoretical device that transcends dichotomous thinking, including the conceptual barriers between the natural and the artificial, it amounts to become a sort of third term, which is characterized by a very high degree of plasticity. It is exactly this plasticity, I contend, that allows the lab members to claim that MDF is a more apposite word to describe the *nature of reality* in which we live, where phenomena emerge not *in* nature or *in* culture, through natural, social or cultural processes, but *in* and *through* massive data flows, i.e. in a relational space linking all these domains. Thus, whether MDF is a metaphor of reality or conflated with reality itself, neither or both, it nonetheless strikes at the heart of anthropological debates about the relationship between figure and ground, reality and representation, words and things, nature, culture, and ontology (cf. Henare et. al. 2007; Venkantesan et. al. 2010).

On the one side, if one understands MDF as simply a metaphor of reality, it is reduced to reside solely in the realm of language and epistemology, which in turn delimits it to the way people use language and symbols to describe and represent reality. Seeing MDF in this way, it becomes a signal in a sea of noise that points to reveal a part of the epistemological orientation of the Ikegami Lab, i.e. their cultural vision on reality. In turn, this allows for the observing anthropologist to make a second-order account about how *they view* the nature of reality. Certainly, though, MDF, as a concept, is an object that gathers and projects a collective view of reality among the artificial life researchers at the Ikegami Lab, a pointer, I think, to how reality itself is constructed at the lab. It is self-evident among them that the categories of “nature” and “culture”, nor “evolution”, can adequately account for the complexity of the real world.

However, on the contrary, it is here once again important to stress that the artificial life researchers at the Ikegami Lab do not simply think of MDF as a concept. Rather, they use it explicitly to make a claim to reality, which means that what is at stake in their use of the word *is* reality itself. If we take this claim seriously, including

Ikegami's contention that, "everything is mathematics"⁵⁰, by which he means that all things, including our descriptions of the world, are part of the world, MDF is not only descriptive of reality but it is also *part* of it, a thing existing *in* the world. Thus, according to this logic, I think MDF can be both an ontology, a worldview and a theory of reality. What is clear, nevertheless, is that MDF is always-already part of reality itself. But if we take this staging of MDF literally, as to what MDF *is* in the context of artificial life at the Ikegami Lab, it makes sense to query how MDF is a useful device for performing an ontology (cf. Blaser 2009).

Thinking about MDF in this way, it can itself be seen as a social tool, as already mentioned in the beginning of this chapter, as something "emerging" in and through social processes itself. Such "social processes", I also want to add, are mainly characterized by Ikegami's mostly successful attempts to enroll his lab members in his own universe of ideas. Moreover, though, this is also to say that ontologies may emerge first and foremost from social interactions and engagements, not something existing prior to these. So, to this end, anthropology has, in the past decade or so, taken the notion of "ontology" in its own direction by referring to the moment-to-moment creation and perception of existence, "the variable sets of historically contingent assumptions through which humans apprehend reality" (Kohn 2015:312). Thus, if one views MDF as socially and historically contingent assumption, as something socially constructed in a moment-to-moment process at the lab, it may equally constitute an ontology. In other words, as a culturally and historically contingent concept that would not have been meaningful, say, 100 years ago, or without taking into account the proliferating networks of communication technologies of our present moment (cf. Thrift 2004), MDF may equally be treated as a culturally and historically contingent ontology, threaded into existence through a slew of historical and social possibilities. Again, still, it is important to stress that the lab members use the term in many different ways, both to make a claim about what MDF-systems are, and how they work, and to make a claim to reality, as a flux of massive data flows, to the point where it conflates with reality itself. And so, there

⁵⁰ Ikegami, during fieldwork, used this phrase to assert that everything, in a loose sense, can be subsumed to mathematics because everything is part of the *same* reality: mathematical equations, descriptions, diagrams, toasters, humans and robots, to name a few, are all *part* of the world, which means that descriptions of the reality cannot be untethered from it (cf. Alexander 2014).

are, of course, acute dangers to the work of untangling the relationship between MDF what *is* and what it purports to *represent*, i.e. reality. Yet, MDF, I want to maintain, remains highly operative to how the lab members envision and make claims about reality *and* to how Ikegami seeks to establish his own paradigm. I will come back to this point later on.

For now, in trying to untangle this relationship between what MDF is and what it refers to, one might find useful anthropologist Ernest Gellner's (2003) essay *Concepts and Society* from 1962, in which he examines the many displacements and epistemological discontinuities separating "our" concepts from "theirs", that is, emic concepts from etic concepts (Gellner 2003). As a precursor to later anthropological debates popularly disseminating into the so-called "ontological turn" (cf. Henare et. al 2007), Gellner challenges the hermeneutic generosity of anthropologists, who, at his time, were rushing to make sense of all indigenous institutions and activities, which eventually made them end up resorting to the idea of a social whole. In turn, this leveraged that if an institution was illogical or incoherent, it was only so because we had yet to make full sense of the social context to which it adhered. Gellner contends that such a view runs the risk of stabilizing the anthropological notion of a "concept" by way of ignoring those social practices that are not viewed as directly contributing to social stability. In other words, this stabilization leaves no space for ambiguity or discontinuity.

Now, if one follows Gellner's critique, the real challenge for anthropology is to formulate and invent concepts that are not "one" with society or the institutions they allegedly represent (Gellner 2003). Concepts, according to Gellner, should rather be formulated such that they cross boundaries and be changeable between and across contexts. Needless to say, perhaps, the concept of MDF is itself invented to cross thresholds between "nature" and "culture", the "biological" and the "artificial", concepts, the lab members believe, which do not fully able to capture the sort of reality we live in. Moreover, if one accepts Gellner's overdue contention, the emic concept of MDF can also be considered a "concept" (an emic term), which nonetheless stresses both a capacity for providing stable meaning to reality (the real world) and a capacity to out-place itself in gathering up disparate meanings across

contexts: as ontology, as method, as explanatory device, and possibly more. That is, in practice, MDF is a concept that sustains itself, I think, exactly by its own plasticity and volatile usage, at once analogous to reality and isomorphic with it: massive data flows are at once “out there” and “in here”; it is what constitutes reality and what we are part of⁵¹

In dealing with MDF as a concept, then, one might still be tempted to treat it as a symbolic category, a mere conception *of* reality. However, doing so, one may also come to deny the existence of what it purports to represent: an ontology of massive data flows. To be sure, while still wobbling on dubious territory, MDF harbors the dual capacity to be at once conflated with reality and still different from it: on the one side, the artificial life researchers use it as a self-invented concept to describe and explain reality (i.e. it provides a new methodology for understanding data flows, the flux information making up reality), and on the other side, they claim that MDF *is* reality (we live *in* an era of massive data flows, all systems alike *are* MDF-systems). Insofar MDF is considered a sort of third term, either epistemologically or ontologically, it accounts for the complex and hybrid material-semiotic networks (Latour 1993), of which we are part, and of which the lab members are part and believe to be constitutive of the real world.

To this end, MDF is in part, I believe, fostered and mobilized to be a theoretical response to already established categories of science (i.e. nature, culture, evolution) by merging the natural and the artificial, the human and the nonhuman under one heading. Such categories are not in and of themselves, Ikegami believes, fully capable of capturing a hybridized reality. On this view, MDF may already offer a sort of parallax view, not necessarily of life, but of reality itself, meant to capture a world that cannot be apprehended by current scientific concepts. But as such, it is nonetheless, not simply a culturally specific indigenous point of (world)view, but rather, I argue, it is also a culturally specific ontology that fuses the purported differences between natural and cultural worlds, including biological and artificial

⁵¹ Much of the thinking animating MDF resounds many of the notions conjured by early cybernetics in the 1950s, for example, when cyberneticist Norbert Wiener proposed to understand social and political oppression as a problem of communication. Cybernetics of the 1950s, and probably also today, cast the entire universe according to the same cybernetic idiom, a universe in which humans and machines are systems of communication trying to keep in sync with their environment (cf. Pickering 2010).

domains, into a one single framework. Furthermore, MDF already challenges the assumption that things like “life” can be apprehended as either natural or artificial, or for that matter that life’s primary ontological unit is DNA. Instead, MDF leverages a single universal framework by which seemingly different and incompatible, and even mutually exclusive, entities can be apprehended simultaneously.

As such, MDF accounts for reality, as a sort of integrated, unified universe, where natural, social and cultural worlds and forces, including biological and artificial elements, cannot be studied in isolation of one another. Or better, MDF offers a relational account of the dynamic relationships between such elements, which should be considered to be inextricably entangled within one another. Now, allow me to elaborate a bit further on this point that MDF is a culturally specific ontology, and not just a third term or simply a worldview, as it pertains to how it becomes politically operative to how lab members are invited to understand reality and how it allows them to challenge dominant “scientific” layouts of reality itself.

The Really Real

Anthropologist Marisol De La Cadena (2010) has shown that the notion of *Pachamama* - the close equivalent to the notion of “Mother Earth” - generated tension in the 2008-Ecuadorian constitution when it entered into regimes of environmental governance (De La Cadena 2010). In this context, the whole concept of Pachamama, De La Cadena notes, is not simply a rhetorical device to reinforce the environmental movement and enshrine environmental care in law. Rather, Pachamama, as it is meant from the indigenous point of (world)view, De La Cadena claims, disturbs the ontological assumptions of modernist views on the world, including the views of the political left and right, and it does so exactly by way of positing the existence of Pachamama as a sentient spirit being (De La Cadena 2010). While the political left, for example, might argue against the industrial and exploitive neoliberal agendas of their opponents, none of them would likely argue for the reality of the environment’s spiritual sentience. In short, Pachamama is, like MDF, an ontological claim in the sense that it posits what things *are* and what the universe is made of.

While MDF might carry with it many political implications, it posits, I think, the existence of data and information as the “really real” to the epiphenomenal world we live in, a world that resides in a sort of “matrix-like” space to which the artificial life researchers are committed (cf. chapter 3). More specifically, though, if information is the basic substance of reality, and MDF denotes how data and information is exchanged, which is supposedly analogous to Darwinian evolution, it points to the underlying principles, which give form, shape and direction to the living world. That MDF is analogous to Darwinian evolution does not only mean that it is thought of as a process running parallel to it, it is also a process *adding* to it; MDF, after all, is “larger” than Darwinian evolution. More to the point, following De La Cadena, MDF is an ontological argument to reality, the really real, that may challenge other ontological arguments to reality, for example those that hold that DNA is the basic building block of life. To this end, MDF disturbs the ontological assumptions of any modernist or realist view on the world, but it also expresses Ikegami’s craving for scientific and conceptual novelty.

Now, in an equally politically-inflected vein, anthropologist Mario Blaser (2009), in his study among the Yshiro people of Northern Paraguay, considers “ontology” from a narrative perspective. On Blaser’s account, ontologies can be enacted by concrete practices and interactions, which means that ontologies do not precede themselves, but are rather “performed” (Blaser 2009:3)⁵². One example of how this plays out is that of a sustainable hunting program, collectively conceived between the Yshiro Nation (Unión de las Comunidades Indígenas de la Nación Yshir) and the European-Union-funded (EU) sustainable development project, “Prodechaco”. In his study, Blaser shows how ensuing misunderstandings between these two groups, through drawing on Viveiros de Castro’s (2004) notion of “uncontrolled equivocation”⁵³ (de Castro 2004), spirals from a profound difference in their understandings of reality, where each group thinks they are focused on the same thing (sustainable hunting practices), when in fact they are not. Blaser further notes that there were signs of this latent equivocation in the earlier stages of the program, but these were initially ignored

⁵² Read: MDF-systems.

⁵³ “Uncontrolled equivocation”, according to de Castro, is a type of communicative disjuncture where the interlocutors are not talking about the same thing, and do not know this (de Castro 2004).

by both groups for various reasons. But the key point in this controversy, as Blaser sets out to show, is that the purported epistemological superiority of the state and the EU-group was enacted such that the Yshiro, he writes, “could *believe* whatever they wanted about the environment, but the actions prompted by these beliefs should not run counter to what the biologists *knew* about the environment” (Blaser 2009:14 my emphasis). As such, Blaser shows how the modern world, or rather a modern ontology, sustains itself through “performances that tend to suppress and/or contain the enactment of other possible worlds” (Blaser 2009:16).

If MDF is an ontology, indeed a culturally specific ontology performed on a moment-to-moment basis at the Ikegami Lab, it may indeed, following Blaser and De La Cadena, be made to suppress other ontologies. If this is so, then, I believe MDF is deliberately made to deviate from any conventional biological understanding of reality, as “the difference that makes a difference” (cf. Bateson 1987:459) in relation to how the lab members apprehend the real world. Moreover, enacting MDF is simultaneously works to *suppress* modernist ontologies and to *authorize* a world to which the lab members should be committed, i.e. an ontologically “flattened” world in which “nature” and “biology” are not the primary units of reality. As such, MDF offers for them a sort of updated view of “nature”, a kind of “third nature” of sorts (cf. Helmreich 1998). This aligns to anthropologist Stefan Helmreich’s own coinage, “silicon second nature”, which is a self-conscious play on notion of the substance or space that artificial life researchers, Helmreich claims, seek to create in computers (Helmreich 1998:11)⁵⁴. MDF, here, is a space outside the computer, the “real world”.

Yet, MDF, of course, is not a computer model. But as a concept it embodies a claim to reality, yet it is still not really a reflection of “first nature”, since it does not seek to mirror “first nature” (the sort of nature hailed by conventional biologists). Rather, MDF is a synthesis of both first and second natures, the real and the simulated, information and physical bodies, seeking to capture the given and the contingent, the rule-driven and the stochastic, the determinate and the random, the organized and the

⁵⁴ Helmreich himself tracks his own term – silicon second nature – back to Hegel’s idea of “first nature”: the given, pristine, edenic nature of physical and biotic processes, laws and forms, with “second nature”, referring to the rule-driven social world of society, the market, culture and the city. Helmreich’s silicon second natures are those natures, which are rule-ordered human constructions, but also devices meant to mirror first natures (cf. Helmreich 1998:12).

disorganized. Still, however, in any case, MDF is a human construction. And as a third term, it is a human construction that applies pressure both to already established understandings of the world and to what reality really *is*. It is, then, a figure of “world-making”⁵⁵ (Stengers 2018), similar to, say, the notions of “Gaia” or “Chthulucene” (cf. Tsing 2015; Lovelock 2009), which are also instances of world-making. MDF is wired to capture, or is at least an attempt to capture, convergent, divergent and overlapping activities, which are both intentional and unintentional, some of which exist irrespective of human control (Tsing 2015). More concretely, MDF may amount to be a device of world-making, picking out an instance of reality as tangled up in heterogeneous, overlapping and excessive streams of data and information that exist irrespective of human control and, at times, beyond human proprioception⁵⁶.

To go back to Blaser, and his notion that performing an ontology may be made to suppress and/or contain the enactment of other possible worlds (cf. Blaser 2009:16), MDF may be potentially be used to display not simply epistemological superiority over other modes of thought in the sense that the lab members try to gain epistemological superiority to dominant figurations of “nature” or of “life”. It may also, I want to suggest, display ontological superiority to other ontologies.

In this ontological sense, MDF is an active reconfiguration of the world, both as possibility and actuality, that attunes the lab members to display both epistemological and ontological superiority to other, often hegemonic, conceptions of reality, which maintain that “first nature” is the ultimate reality. As such, the lab members see MDF as *adding* a new ontological dimension, or in their words, “layer”, to the study of life, one by which Darwinian evolution is not the *only* set of principles giving rise to life. Still, MDF is not made to denounce the principles of Darwinian evolution, but rather supposed to build upon them in order to fathom a sort of reality in informational overdrive, which may well, however, operate according to similar principles: The

⁵⁵ The notions of “Gaia” and “Chthulucene” for example, are concerned with world-making in the way they capture, or attempt to capture, divergent and overlapping activities, often unintentional, many of which exist irrespective of human control (Tsing 2015). MDF is not really “nature”, but perhaps closer to being Gaia or Chthulucene.

⁵⁶ Keep in mind that MDF denotes a world, which is not only suffused by massive data flows, but flooded by it.

Internet, as we have seen, for example, is marshalled as live example of an MDF-system that “evolve” much like organisms do in natural evolution. But in its radical definition, MDF posits that we are not only *of* Darwinian evolution, as the culminations of biological processes, circumstances and organic substances, but also, and perhaps more likely, *of* MDF, in the sense that MDF is conjured to *enfold* the biological within it in order to expand the purview of the living world to include more than the biological.

Hence, MDF, is a both a “third term” that offers a new framing of reality, which is premonitory to theorize life, and an ontology that becomes politically operative to call upon radically alternate worlds (cf. Henare et.al. 2007; Kohn 2015). Indeed, as I will also claim, MDF is a notion that solidifies and embodies what the lab members at the Ikegami Lab mean by artificial life being “larger” than biological life. But more significantly, the invention and introduction of MDF, I think, is vividly expressive of Ikegami’s yearning for novelty and theoretical innovation. Yet, meanwhile, as Oka and others also suggest, artificial life is a “science” in the sense that they really care about how “things work”, and thereby they also cast themselves as “real” scientists, who are not simply solving practical problems, for example by building computer models or other technical contraptions. Rather, they are scientists with grit, who engage in the arduous labor of producing new theories and concepts, not simply solving puzzles.

But, in terms of MDF, I claim that is first and foremost a culturally and historically contingent ontology, which also, perhaps conveniently for Ikegami, the explicit effect of being a sort of a social tool with which to display the intellectual and theoretical prowess of the Ikegami Lab. And as a social tool, it also becomes expressive of Ikegami’s larger plan and desire to establish a new paradigm, indeed, a new way of seeing and attending to arguments and the world at large. Now, in the final section of this chapter I want to summarize this chapter and unpack how this ontology of MDF is also considered by Ikegami to be a, “source of emergence”, that is, as a site from where new (living) phenomena may emerge.

An Ontology of MDF

Ikegami solidly believes that MDF is “a source of emergence”. This means that thinks of the real world as a sort of data-rich and information-glutted cradle from which, he says, “life may potentially emerge”. If life is an “emergent phenomenon”, as Ikegami reassures me, one must accept that, “MDF is the mother of emergent phenomena”⁵⁷, by which Ikegami is explicitly suggesting that the conditions of possibility for emergence begins not in the exchanges of biological substances, nor with computational media, but with the coming-together of massive amounts of data and information fluctuating the real world.

However, as I highlighted in chapter 3, even though many of the lab members believe that information governs everything and while they subscribe to a cybernetic vision of the reality, they also insist upon granting priority to the material specificity of life’s forms. Hence, they actively grapple with the relationship between what they call the “information layer” and the “physical layer” in coming to terms with “life”. That is, as we also saw in the previous chapter, hurricanes, humans, and machines may be complex dynamic systems, even MDF-systems, but they are still *different* systems because each of them are characterized by the kinds of messages or types of information they are capable of receiving and sending. Some forms of information are not automatically commensurable with other forms, and vice versa, as some systems may not be wired to receive or send certain types of information, and so on. Keep in mind here that Ikegami extends the meaning of information to include not just some intangible, free-floating form, but also very tangible material forces. In short, the material specificities of any system matter in terms of what kinds of information become relevant, which is also what enables the lab members to differentiate one system from the other.

⁵⁷ Anthropologist Stefan Helmreich (1998) has shown, in his ethnography among artificial life researchers at the SFI, how normative notions of “fathering” inform the ways they “play God” when attempting to make “life” (Helmreich 1998:120). Despite of such motifs being quilted into artificial life talk, some researchers wondered whether artificial life might basically be seen as an expression of male researchers’ “birth envy” (Helmreich 1998:120).

To this end, MDF-systems may equally be systems of interconnected information circuits, composed of other systems and subsystems, and components of larger systems, as are material objects and social organizations, etc. At the heart of such an observation is that any system is emergent, always-already able to push into the adjacent possible. And so, taken to its logical conclusion *everything* is emergent. Meanwhile, given the extreme plasticity and Platonism of MDF, the lab members may then describe and identify just about any given thing in the world as an MDF-system simply because the dynamics, by which any given phenomena are organized, are based on the same set of principles. Yet, none of them claim, as we have already seen, that humans are similar to hurricanes, but that there are elements of their respective behaviors and modes of organization, which are more or less the same if not outright identical.

That said, to go back a bit to discuss this relationship between the “information layer” and the “physical layer”, or between information and the materiality of the world, anthropologist Nigel Thrift (2004) may once again be helpful. In many accounts of contemporary “information societies”, Thrift notices, “information” is often taken to be a monolithic entity, which is essentially disembodied and intangible (cf. Thrift 2004). However, the lab members do not account for information as completely disembodied. But this does not mean that the lab members stray from seeing information as a monolithic entity, but one that is not essentially disembodied. As MDF clarifies, data and information, after all, may include material and immaterial entities. Yet, according to Thrift, the standard view often goes that the increasing pervasiveness of computers and electronics communication networks has generated a world in which, “a numerical flux [...] is central to activities rather than incidental” (Thrift 2004:590), a pervasiveness that reconfigures space as highly abstract, in which one, “assumes that there are fixed reference points, cardinal dimensions and the like.” (Thrift 2004:590). On this view, computers and electronics communication have given rise to a variety of so-called “flow architectures”, which render the world “reconfigured as a global trading zone in which network forms, which strive for co-ordination, are replaced by flow forms which strive for observation and projection” (Thrift 2004:590). To this end, one can easily argue that there are not, in principle, any essential incompatibilities between, say, humans and machines, since they may

both be emerging through in “trading zones”, as material nodes in a larger network of flows. Thrift further notes that such a view not only produces, “shifts in what is understood as ‘human’ but also shifts in what is understood as ‘environment’ since, increasingly, the ‘artificial’ environment is sentient and has the feel of a set of ‘natural’ forces blowing this way and that.” (Thrift 2004:591)⁵⁸.

Anthropologist, Karin Knorr-Cetina (2004), too, elaborates on the idea of flow architectures, which she prefers calling “timeworlds” or “flowworlds”,

In a timeworld or flowworld [...] the content itself is processual – a ‘melt’ of material that is continually in flux, and that exists only as it is being projected forward and calls forth participants’ reactions and contribution to the flux. Only ‘frames’, it would seem, for examples, the frames that computer screens represent in a global financial market, are presupposed in this flowworld. The content wherein some action takes place, is not separate from the totality of ongoing things. (Knorr-Cetina 2004:40)

Thus, if MDF is a sort of flow architecture, indeed a timeworld or flowworld, it is a “trading zone” in which a “strive for co-ordination” is not necessarily “replaced by flow forms”, but is indeed required to be “projected”. MDF describes “melt” of materiality that is continually in flux, but it does not necessarily dissolve it. Quite the opposite, since “life” is not captured, or in the words of Knorr-Cetina, “framed” by computer screens, it needs instead to be rendered “real” in the real world. However, in the world of MDF, there is not just information, let alone that fact that there is always-already too much of it, but there is also materialities and energies flowing alongside information.

Following Thrift and Knorr-Cetina, then, flow forms need not be projected in the sense that they need to be predicted, but rather in the sense they need to be *projected onto something else*, that is, to be extended outwards, mapped onto, or churned or molded to material and aesthetic ends. What this means in the context of the Ikegami

⁵⁸ Thrift also makes the point that such a worldview is challenges the idea of a Spinozian universe of geometrical laws, which re-naturalize the universe as one that has been constructed or can be constructed rather than one necessarily extant (cf. Thrift 2004:591).

Lab is specifically that data and information must be harnessed somehow in order to construct new embodied systems, such as robots, which are able to interact within and with the real world. Flow architectures organize flow architectures. More precisely, this means that the lab members want to “amplify” their systems by staging them in “real world dynamics,” in “massive data flows”, in order to conduct new types of analysis, which may otherwise be inaccessible to them. Ikegami explains,

I think that people understand that it's easier to implement self-reproduction, sort of evolutionary processes, and homeostatic structures, in a computer. But you don't find life systems over there. So, we noticed that self-reproduction, evolution and self-maintenance, homeostasis, and all these fancy words, are insufficient in order to define life. Even if we implement them it does not make something into life. So again, what is missing? People like me and my lab try to bring life back to the real world. [...] Our goal is not black or white, it's not our goal to say this is alive and this is not. We don't need the notion of life in order to describe the moon or the sun, or any physical phenomena. Words like self-reproduction, and so on, are useful to describe life, but still somehow, self-reproduction keeps returning to the conventions of physics, so there's nothing new to this. We cannot describe what life is purely by physics and chemistry. Artificial life is about bridging the gap between physics and chemistry and, sort of, spaces of meaning.

What is missing, Ikegami seems to imply, is a new mode of apprehension, by which we should not simply seek to describe phenomena in mechanistic terms, but rather seek to make new *meanings*. In other words, the task is to create new meaning of life, by which Ikegami means that scientific descriptions of worldly phenomena and informational dynamics do not *automatically assume meaning*. Rather, creating meaning, according to Ikegami, requires affective, interpretive and hermeneutic labor: life is what is to be made meaning *of*, that which should be apprehended and translated into new meanings *beyond* the sort of meanings inferred by science, particularly physics and chemistry, i.e. by well-worn, established scientific formalisms.

Thus, to summarize, MDF is a culturally specific ontology performed by Ikegami, in part, to guide the ontological orientation of his lab. And so, MDF is a convincing rendition of reality, both large-scale MDF-system and as a sort of flow architecture that needs to be projected, the reality in which we live, and in which information can be apprehended, collected, parsed and classified in new and alternative ways. To this end, if MDF is a term that consolidates what they mean by the “real world”, indeed what I claim is a claim *to* reality, it may also be seen as forming the first part of Ikegami’s nascent “ontoepistemological” that I call Ikegamianism – Ikegami’s own ontoepistemological framework. Indeed, Ikegamianism is a core component of Ikegami’s desire to generate and articulate a new paradigm in science. And so, to go back a bit, it is by articulating *MDF as an ontology* that Ikegami is allowed make a claim to reality. But it also becomes a social tool that may be mobilized to demonstrate artificial life’s ability to construct worlds of their own.

Thus, if MDF constitutes the “onto” in Ikegamianism, as I claim it is, it is nonetheless only the beginning, as Ikegami also seeks to articulate what he calls a, “new epistemology of artificial life”. In the next chapter, then, I explore what Ikegami means by this “new epistemology of artificial life”, and thus how he consolidates his onto epistemological framework I call Ikegamianism. And by this, it is necessary, I believe, to also take a closer look at Ikegami himself, as a charismatic leader at the Ikegami Lab.

5

ATTUNING TO THE EMERGENT



Takashi Ikegami ruminating. Ikegami is the head and namesake of the Ikegami Lab. He is by many of the lab members seen as a “creative” genius, who, “does everything Alife”. In this photo, he is seen in what I came to call the “Ikegami-pose”, a posture he would usually take when someone asked him a question. His style betrays that of an austere scientist and the visionary artist. Photo courtesy of: author.

Introduction: Boring Calculations

Ikegami looks up after taking a sip of his coffee I had fetched for him at the convenience store next to campus and suddenly exclaims, “science is mostly boring ... boring calculations, and so what!?” Ikegami and I are sitting in his office one clear day in spring 2017, when he suddenly starts ranting against what he calls “normal science” - a mode of science he sees as impassionate, objective and ultimately indifferent to the “real world”. Prior to our meeting, we had lunch together close to campus and we began talking discussing how artificial life was different from other fields. It was different, Ikegami assured me, mainly because it was *not* normal science. Back at the office, Ikegami elaborates on our ongoing discussion and tells me that, “normal science” is mostly about apprehending what he otherwise sees as an exciting and lively world. Those who do normal science are essentially, he says, making “boring calculations”. And so, doing normal science, in other words, fails to recognize and appreciate that some things are incalculable and therefore cannot be easily translated into the language of science. Needless to say, normal science, to Ikegami, is “boring” and should therefore be avoided. At least if one wants to be an innovative and creative scientist.

As I listen to Ikegami’s disapproval of normal science, I notice that his style betrays a tension between the logical and rigorous figure of the scientist and the creative and spontaneous figure of the artist. Ikegami’s appearance - dressed in a colorful Jackson Pollock-patterned shirt, worn-out sneakers, his dark fuzzy hair, slim face and body - immediately betrays any prejudicial image of a stereotypical, white-coated scientist. In fact, from the looks of it, I notice that he looks more like the famous Japanese rock singer Kiyoshiro Imawano, or someone like Mick Jagger, than an actual scientist. However, his looks, I further notice, are supplemented by his words and his larger-than-life-personality, assuming a sort of Jungian archetype: the artist-scientist. His style, then, both betrays that of the rational and stale scientist, but also that of the creative and spontaneous artist, who dreams and ruminates, who gets easily distracted by his own thoughts so he has to be pulled out of the rain. He is somehow in between these two archetypes, simultaneously embodying both and being neither of them, vastly knowledgeable, rigorous, and objective, curious, spontaneous and impulsive,

and not least creative. And indeed, when Ikegami is not busy talking to me, teaching, researching, or trying to convince scientists of the inadequacy of “normal science”, he rejoices in going to art exhibitions, play electronic music, conduct concerts, and indulge in various art-science events around the city of Tokyo. He is, in other words, *not* someone who would fit into his own depiction of normal science.

Normal science, according to Ikegami is thus a mode of science he opposes, a mode strongly based on the doctrines of objective representation, and as such, it is closely related to, if not synonymous with, the sort of normal science identified by philosopher of science Thomas Kuhn (1962). Kuhn’s notion of normal science, like Ikegami’s, is characterized, or perhaps caricatured, as a kind of science by which scientists theorize, observe, and experiment within a rigid, fixed and settled paradigm (Kuhn 1962). They are, in the words of Kuhn, simply solving “puzzles” without pushing the boundaries the paradigm under which they work. Similarly, in the words of Ikegami, they are simply making “boring calculations” without pushing the boundaries of the paradigm under which they work. They are, in other words, slaves to what Ikegami refers to as their own “frames of reference”.

And so, standing opposed to, and working against, normal science, Ikegami and the lab members, I learned during fieldwork, are engaging in outlining the contours of what Ikegami calls, “a new epistemology of artificial life” – an epistemological framework based on embodied modes of knowing, more aligned to a sort of post-phenomenological approach to the “things-in-themselves”, as they appear in materially, socially and culturally structured worlds (cf. Hasse 2008). This new epistemology of artificial life is first and foremost about developing *embodied* and *affective* responses to the things they are constructing at the lab, by which, as anthropologist Cathrine Hasse (2008) writes, “knowing subjects become knowing embodiment” (Hasse 2008:45). But more importantly, such an epistemology of artificial life, Ikegami hopes, may therefore counter the hegemonic paradigm normal science by shattering the doctrines of objectivism and scientism that he believes are inherent to normal science. In short, normal science is characteristic of paradigm under which practitioners are largely suffering from a disregard for experienced reality (cf. Bourdieu 1977).

Ikegami, then, as we saw in the previous chapter, seeks not only to create his own ontology, but he also seeks to build a new way of doing science altogether, indeed, a new epistemology. In a word, a new epistemology of artificial life, Ikegami tells me, relies not so much on strict scientific formalisms or the cold rationalities of science, but rather on an embodied mode of knowing that acknowledges, following Bourdieu (1977) experienced reality. And as already made clear in chapter 4, this reality is highly stochastic and unpredictable, a jumble of “massive data flows”. A new epistemology relies, then, on somehow teasing out new, even more capacious and nuanced *meanings* of life upon a mode of embodied knowing, following Hasse, in the sense that knowing subjects become knowing embodiment. In a word, Ikegami calls attention to the idea that one may indeed sound out new meanings of life more impressionistically.

If one of the central goals for the lab members of the Ikegami Lab is to construct artificial life in the real world, then doing so is not simply an end in itself. It is also, I believe, what allows them to create new *meanings* of life, meanings that expand beyond the sort that can be generated by established scientific formalisms. In order to create new meanings of life, from the jumble of massive data flows, one has to change perspectives. As Ikegami notes, “in the real world, I’m part of the world, and it is from here we want to describe it, from a first-person subjective perspective”, and so a new epistemology of artificial life, Ikegami believes, is therefore not only necessary but vital to how we are supposed to know and understand life. This epistemology is therefore inextricably tied to and rooted in the ontology of MDF that we saw in the previous chapter, and to this end, as Karen Barad (2007) also notes, following physicist Niels Bohr, I want to recognize that epistemological and ontological issues are always-already inseparable, which means that the nature of knowledge cannot be separated from the nature of being (Barad 2007). For my convenience here, I want to show here how Ikegami’s new epistemology of artificial life cannot be untethered from the ontology of MDF.

Thus, in this chapter, I want to attend to two interrelated themes when unpacking the relationship between epistemology and ontology, between “normal science” and the “new epistemology of artificial life”. The first theme concerns Ikegami himself, as a

self-described artist-scientist, whose charismatic authority, charm and wit, I want to show, are primary engines of agency at the lab. Ikegami's flamboyant and bombastic personality and his style of leadership are traits that allow him to command his lab. Following sociologist Max Weber (1954), and his notion of ideal types of legitimate leadership, authority and domination, I discuss how Ikegami becomes a charismatic leader, who makes "sacred norms", which are produced by his word (cf. Weber 1954; Spencer 1970). Such "sacred norms", I hold, are embodied in what I call Ikegamiansim, in turn, constituting a sort of creed that offers guidance to the lab members and to which the lab members adhere. Indeed, during fieldwork, I often noticed how Ikegami was by the lab members – or rather his "followers" – described as a "genius", "creative artist" and a "source of inspiration", and many of them viewed him as a sort of prophet or pioneer. As a sort of prophet or spiritual leader, whose personality, charm, wit, and style of leadership, generates sacred norms, I want to suggest that scientific practices at the Ikegami Lab are primarily motivated by Ikegami's ability to, "destroy old norms and create new ones" (Spencer 1970:125). Ikegami is, in other words, a main character and primary engine of agency to how things get done at the lab, at least when it comes to providing the overall philosophical, metaphysical, ontological and epistemological orientation of the lab.

Now, while this first theme concentrates on Ikegami himself, and his role as a charismatic leader, the second theme is concerned with the intrinsic meanings of his new epistemology of artificial life. This new epistemology, if seen in relation to Ikegami as a prophetic leader, is basically a gospel about learning how to attune to the emergent in offering a way to learn how to apprehend surprises, the serendipitous, and to be sensitive to that, which emerges beyond the technical specifications of the phenomena under observation. Thus, for example, if the models seen in chapter 3 are objects made significant *because* they are pushed to offer empirical evidence of the ontological continuity between seemingly disparate cases of behaviors (such as the flocking behaviors of boids and birds), this new epistemology, in particular, is about learning how to *sense*, or in the words of Ikegami, "how to pick up", some emergent signature, or trace, of vitality. This requires an embodied gaze; indeed, it requires what Ikegami calls an, "internal observer," and learning to "pick up" the emergent, then, is perhaps best illustrated by microbiologist Minakata Kumagusu (1971) and his

notion of “tact” – a heightened attentiveness and receptive attitude to the surprises of things, even things that might lie hidden in plain view (Kumagusu 1971; Kumagusu 1951; Delaplace 2014:54). Tact, for Kumagusu, is not an antonym to reason, nor something simply synonymous with the intuitions or inspirations of genius. Rather, it may be said to be an intensified affective and embodied limit point, where that which one has consciously learned suddenly encounters worldly surprises that go beyond this learning (cf. Kumagusu 1951; Kumagusu 1971; Kumagusu 1973). “Life”, on to this view, is basically semiotic, through and through, the product of sign processes (cf. Bateson 1987; Deacon 1997), and learning how to *read* these signs of emergent vitality - signs that are not immediately visible to us, but potentially experientially available to us in some impressionistic sense.

Finally, it is important to keep in mind when unpacking this new epistemology, however, that Ikegami’s charisma and style of leadership, I want to maintain, remains a central component in inciting, enrolling, mobilizing, and captivating the lab members. That is, in short, Ikegami’s charisma is key to his success in terms of whether he fails or succeeds in convincing his lab members that they are indeed working to establish a new paradigm. So far, for example, it is clear that all the lab members subscribe to the idea that normal science is bad. But, Ikegami’s desire to build his own paradigm, I also want to show, is also vividly expressive of his authoritative role at the lab *and* at driving force at the heart of Ikegamianism. Put differently, this so-called “new epistemology of artificial life”, I hope to show, is inextricably linked to the ontology of MDF, but it is also an important part of Ikegami’s attempt to articulate a creed, i.e. to articulate a set of beliefs and norms that guide lab members’ actions. But now, I want to begin by reiterating a story told by Ikegami about how science, “makes a beautiful world” in order to explain what he means by “normal science” and how this relates to “a new epistemology of artificial life”.

Science Makes a Beautiful World

Science, to Ikegami, is basically one among many “layers of description”. Other “layers”, he says, may include art or religion, even other ways of knowing the world, for example, through reading, through sensing, or through making calculations. Our access to reality, in other words, is always mediated. Likewise, science – this vastly abstract term – is a layer, Ikegami claims, which is uptight with formalisms that find their most canonical expression in mathematical equations and chemical formula, but also in models, illustrations and diagrams (cf. Jay 1988). Science, in other words, is a specific mode of mediation that is essentially, Ikegami claims, undergirded by a strong rhetoric of universalism, remaining mere representations of what they purport to represent. They are, simply put, optics or lenses through which to know the world.

To better understand what Ikegami means by normal science, as a layer of description, including its associated layers of description, such as equations or models, it might be useful to listen in on some of Ikegami’s stories about friends and colleagues, who had over the years gone off to do what he refers to as “real science” in other fields outside artificial life. One of such friends, I learned, was and still is a close friend of Ikegami: biologist Charles “Chuck” Taylor at the University of California Los Angeles (UCLA), who had, Ikegami tells me, “stepped down from artificial life because he wanted to do experiments the real birds and not just boid-models”. Others, however, had fled the field of artificial life not necessarily to do “real science”, but rather to pursue and establish careers in less precarious and more career-promising fields, wanting rather to make universal findings or commercial applications of their research. Thus, “after 20 years or so,” Ikegami continues,

people got more interested in doing ‘normal science’, you know, concerned about how and where to publish papers, in which scientific journals, and stuff like that, so that kind of killed the field. Playing with ‘toy models’, and doing the kind of experiments we do, people believe have no universal value. And the journals don’t care about such things [...] the entire tendency has changed drastically, so now people want to publish in big journals, like ‘Nature’, and so on. And people doing

artificial life, too, don't want to play around with 'toy models' anymore, but seem to go off to computer science or synthetic biology because they want to work with 'real' cells and deal with molecules and things like that.

One of the many motivations for why people are leaving the field of artificial life, in the words of Ikegami, is because, "people seem to be more curious about finding universal features of life, and if you deviate from this ambition, you're ruled out, it's not science," but Ikegami also reassures me, "I don't like that tendency." Now, Ikegami's story here marks some important differences between what counts as "real science", or simply "science", and non-science. But it also marks, I believe, a structure of feeling in him of a sort of inferiority to what counts as science to begin with: someone or something somewhere has mapped the rules of science, by which artificial life, according to Ikegami, are out of bounds. More importantly, though, what is missing, he believes, from science is playfulness or at least the willingness to be different from the prescriptive norms of normal science.

Now, according to Ikegami, science is only *one* among many layers of description, noting that science is basically about, "making descriptions and equations of the natural world," and then claim that, "these are the basic equations for this and that." Science, to this end, lack, Ikegami believes, modesty and more importantly an open attitude to other perspectives and interpretations of the world. Moreover, what he means by people wanting to find "universal features of life", then, is that they want to make "rational" equations that formulate some universal law describing what life *is* in some absolute sense, i.e. a belief that life can be reduced to, and adequately known, by an equation. Yet, as Ikegami reports, "writing down equations is something scientists do to understand something about the world. Equations are for human beings. I don't want to describe life by saying, 'ok, this is the concept to understand life' or, 'this is the equations for living systems' or 'this is the material you put into the system to make it alive'." In other words, scientists should not only allow for alternative readings of the world, but also actively pursue new readings that are not necessarily automatically legitimated on the basis of, say, mathematical equations. That is, it is not simply about making some new mathematical equation, but it is

rather what comes next that matters, asking instead what a mathematical equation might tell us about the thing it refers to.

Thus, the fact that scientists make equations to understand the world, as Ikegami notes, is a way to make “nature” or “reality” calculable, and if it cannot be made calculable, it is not, as Ikegami further notes, “real science”⁵⁹. “Real science”, it must be noted is here also interchangeably being mixed up with “normal science”, but it basically refers to the same sense of science, as a sort of universal belief system, which is couched firmly in the idioms of “rationalism” and “scientism” – beliefs that opinions and actions should be based exclusively on reason and knowledge rather than, say, on religious belief, affective or emotional responses. Moreover, normal science is a paradigm, according to Ikegami, in which scientific knowledge is believed to have direct access to “nature” and therefore to “truth”. Again, Ikegami asserts, there are other truths to be observed, indeed to be interpreted, if one indulges in doing things differently.

Ikegami’s portrayal of “normal science”, I came to notice, resemble in many ways the kind of “modern science” that sociologists Theodor Adorno and Max Horkheimer’s (1971) had set out to rebuke during the 1930s and 1940s, although doing so for slightly different reasons than Ikegami. Horkheimer and Adorno, in their own disapproval of Enlightenment science, view “science” as basically an enterprise seeking to disenchant the world by extirpating “irrationalities”, such as magic, animism and vitalism in wielding an unprecedented and authoritative judgment on “nature” (cf. Horkheimer & Adorno 1971). On this view, science and conventional scientific formalisms, as it were, are geared to make nature calculable, and in the process, ends up conflating calculability with usefulness, sometimes even meaning. The basic mistake among scientists, as Ikegami also asserts, is exactly to confuse, say, mathematical equations (as scientific representations and epistemological tools) with

⁵⁹ Read: *The Word for World is Massive Data Flows* (cf. chapter 4)

“reality itself”⁶⁰. This does not mean, though, that equations, as representations of a given phenomenon or some physical reality, cannot be useful, but rather that they cannot explain *everything*. Indeed, the way they are used as absolute and authoritative accounts by scientists, according to Ikegami, is what makes them disenchanting of a world he sees to be substantially richer and more complex (cf. chapter 4).

Normal science, then, is according to Ikegami engaged in making “nature” calculable to the point where the materiality of nature conflates with its measure, taking it most canonical expression in mathematical equations. Now, as Ikegami for obvious reasons contends, normal science is *not* the only way to make sense of reality, nature or the physical world, but simply one among many ways to describe and make sense of the world at large. Hence, to go back to Adorno and Horkheimer’s rebuke of modern science, and insofar theirs was a rebuke of a specific “layer of description”, Ikegami seeks to rebuke the “layer of description” of normal science. He reports,

Irrationality does not exist in the natural sciences. There’s no such thing as irrational chemical reactions or irrational mathematics. Irrationality appears unique to human society, but scientists behave like it doesn’t exist. For example, if your house is flooded by a Tsunami, but the house next door is untouched, you would probably wonder, ‘why does this happen to me?’ And that’s actually the problem! On a general level, we would measure the damage by saying, ‘a certain area was devastated by the Tsunami’, but on your level, the ratio of damage is one to one. Even if 30% of a particular area was destroyed, it won’t necessarily mean anything to you. Your problem is whether you were affected or not. So, we need to have people share these emotions. But since irrationality

⁶⁰ Historian of mathematics Amir Alexander’s (2014) brilliant book *Infinitesimal: How a Dangerous Mathematical Theory Shaped the Modern World*, addresses this problem in telling the story of how infinitesimals - the ground for general methods of the integral calculus known today - during the mid-17th-century became controversial for the Catholic church, who feared that such indivisibles placed paradoxes at the heart of God’s creation, confusing matter with its measure (Alexander 2015). The materiality of the world, Alexander implies in his book, cannot be untethered from the formalisms people used to describe it. Yet, debates in mathematics have been waged for centuries on how to calibrate matter with its measure.

doesn't exist in physical science, you don't even have to think about what it means. If we don't understand those things, if there's no such thing as irrationality, then we'll all be content. If we only had to use physics or chemistry or mathematics, then everything ends right there, but our world is on a different level. We need to think about connections. Irrationality appears from nowhere. It emerges just like time emerges, and that's what society's like. Instead of trying to resolve irrationality we should simply recognize that it's there and think about what we can create from it. If we don't do so, however, a beautiful world will continue to exist. Physics, chemistry, mathematics are equivalent to a beautiful world ... Yet, the basic rule for a scientist is not to believe in mystery, but in a way, scientists keep believing in illusion, magic, and mysterious things.

Ikegami's emphasis on *meaning*, again, suggests that the "layer of description" of normal science, especially physics, chemistry and mathematics, generally fails to make proper meanings of any given phenomena, for example, such as the damage ratio of a Tsunami. What matters to the scientists, who act as proponents of normal science, is to shore up such an event by making "objective", rational calculations, and then even reduce it to such. However, there are ways to break up with this scientific vision of the world, as Ikegami continues, "but science is also the body of a community. And what the variable is must be determined by the community itself. Basically, you can say what you want to say. Science is really a matter of community."

Now, there are a lot of things going on here: what Ikegami is basically suggesting is that scientific formalisms, especially mathematical equations and chemical formula, are clumsy mediators of reality. Indeed, harking back to the previous chapter for a moment, computer models, equations, diagrams, scribbles, formula, words, theories, may even be said to be clumsy mediators of a highly complex and excessively information-flooded reality. Yet, still, this does not mean they are not useful, but simply that they should not be mistaken for being anything more than representations of reality, and very bad and heavy-handed renditions of that reality. They are, to be sure, nothing more than *descriptions* of reality, but nevertheless still part of reality. As such, they do not possess any real explanatory power, but remain descriptions.

However, this does not mean that such descriptions are unreal or inauthentic, but simply that they are useful descriptors of reality, and thus exist in the world, which should not, however, be taken for more than what they are.

But in addressing that science is a community - indeed a community of people who work under the same heading, “science” - Ikegami is also allowed, I think, to open up the possibility for breaching the doctrines of normal science by critiquing the norms and forms of settled expert authority (cf. Enwezor 2012; Franceschini 2017). In other words, recognizing that science is flecked with a slew of rationalities, some of which may be less embedded in cultural participation, none of them, especially not normal science, are “culture-free” (Tambiah 1990). Indeed, on the contrary, as Ikegami suggests, the criteria by which one assesses truth or veracity is determined by the “community”, which is to say that it is determined by the given “cultural formation” at that specific time and space. This notion, I think, also applies pressure to the criteria for determining what counts as “scientific”, what counts as “scientific knowledge”, and what counts as proper scientific conduct in terms of research. Normal science, then, is a distinct, culturally-enclosed space, or community, akin to what philosopher of science Gaston Bachelard (1998) has called, “kernels of apodicticity” - those regional “rationalisms” that are entrenched within specific epistemic territories (or what he calls cantons) by which objects are assessable only in relation to specified epistemic matrices (Bachelard 1998).

Ikegami’s depiction of normal science, then, casts it as an arbiter of universal truth, even though it is, in fact, a community of people, who simply share a “culture” of “objectivism” and “scientism”. But really, according to Ikegami, and if one follows feminist scholar Donna Haraway (1988), scientists share a “partial perspective” and in doing so, they decide upon their own rules of apodicticity and criteria of veracity, which are nonetheless, to Ikegami, *contestable*. As such, Ikegami’s version of science is also one resounding one of the central claims of Actor-Network Theory (ANT) – a theoretical and methodological approach to social theory where everything in the social and natural worlds co-exist in constantly shifting networks of relations – where the production of “facts”, as anthropologist Bruno Latour argues (1987), is simultaneously the process by which such “facts” come to be accepted as facts. How

facts become accepted as facts, Latour says, depends on which supporters are enrolled and how actor networks are extended by trials of strength until the cost of dissent becomes too high (Latour 1987). In other words, central to Ikegami's claim is that the "facts" of normal science have failed to enroll them as supporters and thus failed at gathering a strong consensus about what constitutes the appropriate criteria for veracity.

A Charismatic Leader

How, then, does one make sure to enroll supporters to gather consensus? Ikegami's charismatic aura, his status as a "pioneer" among the lab members, and his unconventional approaches, I think, is exactly what persuades lab members that normal science is generally bad. Moreover, Ikegami's status as a sort of spiritual leader among the lab members is exactly what motivates belief in the idea that a new epistemology is needed, indeed, that a new paradigm of science is required for making new meanings of life. And this is exactly, I believe, what allows Ikegami to destabilize and challenge the entire scientific enterprise itself: he is a charismatic leader, who is confident that he is on a righteous path, and as such, he is also confident that he can open a new space of possibility for articulating fresh rules of apodicticity and criteria of veracity and truth.

But in order to establish himself as a trustworthy leader, it depends first and foremost on his ability to renounce normal science and on thus convincing us that normal science is detrimental to scientific progress. So, one has to be convinced that the "hard facts", which may, according to Ikegami, easily come undone, are negotiable, not axiomatic. Once one accepts that, Ikegami is allowed to say that scientists, who usually tend to say they enjoy exclusive and absolute access to the truth of nature and its operations, in fact only enjoy only a partial perspective (cf. Haraway 1988). This is, of course, part of Ikegami's strategy to denounce normal science, to say that we only enjoy a partial perspective on things. Denouncing normal science therefore depends on Ikegami's ability to deconstruct it, but only as a way to construct his own paradigm, that is, to reconstruct the outlines of kernels of apodicticity by which to

assess truth. To this end, Ikegami simply joins a cacophony of anthropological and sociological voices, who have spent the past fifty years deconstructing science. But evidently, Ikegami's own deconstruction of normal science, I think, here serves a very specific purpose: deconstructing normal science allows him to reconstruct a new mode of science. As such, Ikegami's deconstruction of normal science, as sociologist Silvia Gherardi (2017) notes, is a sort of "local tailoring", which is seemingly invisible to the whole group – i.e. the lab members – but nevertheless constitutes a shared representation of normal science. Ikegami, then, vexes on on a, "regime of visibility/invisibility" (Gherardi 2017:bp), not in order to make normal science "invisible" as such, but rather to make artificial life *more* visible. After all, normal science to Ikegami and the lab members is a visible adversary.

If the deconstruction of normal science, then, is an active strategy, indeed a sort of "local tailoring" allowing Ikegami to admit new definitions of what counts as a proper kernel of apodicticity, by which to evaluate and assess truth, then doing so, I think, vividly exposes how Ikegami embodies a certain type of authority at the lab. In the words of Gherardi, it, "illustrates the way in which classifications perform courses of action in an invisible manner" (Gherardi 2017:bo). Ikegami's vision and deconstruction of normal science thus dissipate among lab members, who adopt a view of science, including its tools, approaches and methods, that it is largely detrimental to scientific and intellectual progress.

As such, Ikegami's version of normal science is somewhat identical to how philosopher of science Thomas Kuhn (1962) describes "normal science, which is an enterprise that attempts to, "force nature into the preformed and relatively inflexible box that the paradigm supplies," where, "no part of normal science is to call forth new sorts of phenomena". Normal science, to Kuhn, is a paradigm, in which, scientists do not, "normally aim to invent new theories, and they are often intolerant of those invented by others. Instead, normal-scientific research is directed to the articulation of those phenomena and theories that the paradigm already supplies." (Kuhn 1962:24). And so, what Ikegami shares with Kuhn's conception of normal science is that "normal-scientific research" largely fails to get at something new. Needless to say, Ikegami represents, or rather makes himself a representative of, the opposite of

normal science, and encourages his students to do the same. This deconstruction of science, in turn, is a display of Ikegami's power and authority at the lab, his ability to do "invisible" work that actively steers the course of action at the lab (cf. Gherardi 2017). Ikegami, then, surreptitiously establishes himself as someone who is by himself able to "silence" normal science by casting it as "inappropriate knowledge", but he also someone, as we saw in the previous chapter (chapter 4), who is able to articulate his own ontology. Now, to this end, he mediates the relationship between what is bad science and what is good science, what reality is and what it is not. And so, he clandestinely smuggles an "invisible infrastructure" of norms, visions and beliefs into the social world of his lab (cf. Gherardi 2017). In other words, he establishes himself as a charismatic leader, whose visionary outlook, personal qualities and emotional posture affect the lab members in ways that make them follow him.

Now, sociologist Max Weber (1954) distinguishes between three ideal types of legitimate political leadership, domination and authority by specifying three more or less distinct types of domination: traditional authority, legal authority, and charismatic authority (Weber 1954). Such ideal types may be manifest in all kinds of organizations, from corporate enterprises to governments, and legitimate all sorts of actions. Now, if scientific practices under the aegis of normal science are governed and legitimated by their adherence to tradition and custom, as Ikegami seems to suggest they are, it is an enterprise largely ruled what Weber calls "traditional authority" – a mode of authority in which an organization (in this case normal science or the scientific enterprise) is tied to tradition or custom (Weber 1954). And if normal science is guided by rules, laws and traditions, as Kuhn suggests, noting that normal science is a "tradition-bound activity" (Kuhn 1962:6), it makes sense to say that normal science is an organization, or a ruling regime, that is largely tied to, and legitimated by, traditional values and customs. And, as Kuhn further notes, in normal science, there must, "be rules that limit both the nature of acceptable solutions and the steps by which they are to be obtained" (Kuhn 1962:38). Thus, Ikegami's notion of normal science is a sort of paradigm governed and legitimated by tradition and custom: scientists, such as Ikegami's friend Chuck Taylor, for example, adhere to a set of rules of doing "proper" or "real" science. However, in addition, normal science

may also fall under Weber's second type of domination - "legal authority" - by which Weber sees a form of leadership in which the authority an organization is bound to legal rationality, legal legitimacy and/or bureaucracy (Weber 1954). But notably, normal science is mostly bound by rules and traditions that must to be followed in order for "science" to be real "science".

Now, charismatic authority, Weber says, is opposed to both traditional and legal authority by virtue of deriving its power from the charisma of the leader himself (Weber 1954; Spencer 1970). Thus, charismatic authority, in contrast to both traditional and legal authority, "sweeps aside old norms and generates charismatically-certified new norms [i.e. '...norms legitimated by ... virtue of *affectual attitudes*...']" (Spencer 1970:126 my emphasis), and so the leader generates the norms and not vice versa. Since authority and legitimacy derives directly from the personal qualities of the leader, affectual action should here be understood as qualities such as positive attachment, awe, fear, reverence, and so on. Key to charismatic authority, then, is that it involves some emotional posture or personal quality as the basis for executing and asserting authority (Weber 1954; Spencer 1970).

Ikegami, to go back, *is* such a charismatic leader, one who generates the norms and whose creeds are followed. That is, I want to claim that Ikegami is a charismatic leader whose visionary outlook, emotional posture, and affectual attitude, *affect* and *propel* lab members to follow his creed and join him on his mission to "construct artificial life in the real world". In other words, Ikegami's, "affect is generated by the personal qualities [...] and is attached to his person" (Spencer 1970:130), and as such he leads his lab by surreptitiously generating new norms, for example, by making evident to us all that science in general, and normal science in particular, is about making "boring calculations". More prominently, I also want to claim, Ikegami is not only convincing lab members that normal science is bad, he is also simultaneously providing them with philosophical, metaphysical, ontological and epistemological guidance. He defines the principles of reality, MDF, as we saw in chapter 4; he defines the principles by which this reality is supposed to be apprehended by denouncing normal science; and he even goes as far as to say that, "one can basically say anything in science [...] so it is the community, who decides what is true and

what is not”. And while such utterances edge on the anti-philosophy of philosopher of science Paul Feyerabend (1975) - things are true if we decide they are, or at least if we agree on the baseline principles for determining what they are or how they work – they also reveal that Ikegami is the one deciding the overall orientation and attitude of his lab, an attitude that is seemingly contagious among lab members.

Now, as Ikegami concludes: as long as scientists persevere in the paradigm of normal science, in their own, self-made kernels of apodicticity, and in turn reproduce this scheme of normal science, “a beautiful world will continue to exist”. Yet, still, the “beautiful world” to which he refers is the world normal science *wants* to see, but this beautiful world only exists because it is framed by normal science. In turn, it is also the vision of normal science Ikegami *wants* his lab members to see, and it is exactly a vision that makes his own enterprise of artificial life seem more novel and radical: in this world, normal science is not only congealed, but largely detrimental to scientific and intellectual progress, and this is why it must be deconstructed.

Deconstructing/Reconstructing Science

Simply put, normal science is characterized by being a set of research practices contained within, and legitimated by, a specific set of rules and norms. This is, at least, how Ikegami and the lab members see it. And as such, normal science is a likely candidate for being the type of clean or “pure” science that orders an otherwise disorderly and “messy” world, characteristic of a modernist paradigm that bifurcates the world into ontologically distinct and purified domains, “nature” and “society” (cf. Latour 1993). Rephrasing Ikegami, then, normal science makes the world “beautiful” exactly *because* it orders the world into neatly demarcated categories. However, as Ikegami contends, he does not really want a beautiful world and he encourages his lab members to adopt the same stance. Rather, Ikegami suggest that we 1) acknowledge that the world is messy in both an ontological and a relational sense, and 2) therefore we must engage such a world, he says, “as it is” without reducing it to the apprehensions and formalisms of normal science. In playing on the dichotomous relationship between the clean and the messy, to follow anthropologist Mary Douglas

(2001), Ikegami not only want reality to be messy and impure, that is, to be what Douglas calls “matter-out-of-place” (Douglas 2001:41), but he also wants to make normal science “out-of-place” exactly in order to make “place” for his new epistemology of artificial life.

If one plays on the relationship between the pure and the impure, the clean and the messy, I want to claim here that Ikegami, as a charismatic leader, is also in the process of calibrating the relationship between normal science and their own enterprise. And this calibration involves the work of deconstructing normal science for the benefit of crafting his own mode of science, on reworking the relationship between good science and bad science, and on reworking the relationship between his own “new” epistemology and his self-articulated ontology of MDF. That is, wanting to formulate a new epistemology of artificial life rests upon deconstructing normal science, but also on the sustaining belief among lab members that the real world is indeed composed of massive data flows, and so an epistemology of artificial life must be defined in relation to an ontology of MDF. Thus, Ikegami’s new epistemology is essentially a response and answer to his own self-invented ontology that posits reality as unruly and ontologically impure, but this, in turn, reveals that Ikegami must mediate the relationship not only between normal science and his own mode of science, but also between epistemology and ontology.

Now, what Ikegami means by the notion that, “science makes a beautiful world” is that normal science practices filter phenomena through its own layer of description. But it also means that scientific practices, in general, essentially endeavor to render clean an untidy and messy reality in an idiom of “rationality”, “objectivism”, and “scientism”. But through his deconstruction of normal science, Ikegami also exposes how he is largely unimpeded by such doctrines, which also enables him to become an adversary of normal science. As such, Ikegami instills a collective attitude among his lab members to cast themselves as rebels to an established order, an order they collectively seek to topple. And this self-imposed image, I think, is no coincidence. Rather, it propels Ikegami and the lab members to imagine themselves as insurgents, who operate at the fringes of science. This attitude, I hold, is rooted in, and animated

by, Ikegami's charismatic authority expressed in his ability to mediate relations between different modes of science, ontology and epistemology.

While Ikegami is the key to understand how the lab members come to share a sort of rebel-identity, it remains critical to keep in mind that he must be able to sustain his charismatic authority. In other words, if the lab members fail to put their trust in Ikegami as a "pioneer" and spiritual leader, indeed, if they fail to remain convinced that the world is flooded by massive data flows, Ikegami would in turn lose his ability to hold on to his followers. So, if normal science represents a certain type of ordered system - or a "culture" if we follow Ikegami's view that science is a community of people sharing the same set of epistemic matrices that brings ontological closure to the messiness of the world with mathematical precision⁶¹ - it epitomizes a specific normal-science-paradigm (cf. Kuhn 1962). As also Kuhn asserts, a normal-science-paradigm configures the world into a set of ordered relations, where practitioners share a specific set of "values", either symbolic generalizations or models. And so, it provides them a sense of community as a whole, what Kuhn terms a "disciplinary matrix" (Kuhn 1962:184). Thus, the disciplinary matrix of normal science is bound to tradition and custom. However, taken to the Ikegami Lab, the disciplinary matrix and the sense of community among the lab members, I hold, is bound to Ikegami's personal qualities and charismatic style of leadership. Indeed, their collective rebel-identity without the Ikegami would potentially collapse insofar Ikegami should suddenly be unable to sustain this disciplinary matrix.

Ikegami not only wants to be the contravention of normal science, but he also asserts that the world *is* essentially ontologically disordered and should therefore be apprehended as such. To this end, following Douglas once again in this language of disorder, complexity, pathogenicity and hygiene, if Ikegami sees that the world is ontologically disordered (the kind of world normal science is in the breach to account for, however, unsuccessfully), or in Ikegami's words "messy", then he wants to keep

⁶¹ To go back here to Theodor Adorno and Max Horkheimer's (1971), this process to make nature calculable, ironically, as they point out, ends up collapsing under its own weight, eventually inverting on itself, becoming that which it seeks to eradicate: an irrational enterprise (cf. Horkheimer & Adorno 1971). That is, the excessive belief in rationality in its very excessiveness slips into what it opposes, ultimately imploding into irrationality.

it that way. And my claim is that he does so because it serves a specific purpose for him: it makes artificial life stand out against the crowd and it allows him to establish and command the disciplinary matrices by which his lab operates.

Now, to take a step back, this is not to say that “science” in general, or doing what Kuhn calls normal-scientific research, is an irrelevant activity for artificial life. After all, much of the field was founded on many of the doctrines of normal science in developing new methodologies and techniques for simulating lifelike processes in silico. But normal science, as Ikegami makes clear, is associated with the ordinary, the familiar and the regular, not the extraordinary, the unfamiliar and the irregular. Put differently, the scientific formalisms of normal science (for example “rational” mathematical equations or chemical formulas) cannot explain *all* aspects of worldly phenomena, but tend to explain them by turning them into equations or formulas, i.e. the conduct “business as usual”. Artificial life is not business as usual; it is, rather about being innovative and creative, about not limiting oneself to assess truth purely by reason, by rationality, by predictability. It is about expanding towards new horizons of possibility and reach for new meanings of life through attuning to the emergent, to serendipitous moments, about qualia and about making affective responses to a living world. But before going further into some of the details of the, “new epistemology”, indeed this embodied and affective mode of knowing, it serves to say here that what Ikegami encourages a belief among lab members to think of artificial life as the contravention to normal science in being extraordinary, unusual and remarkable. Thus, allow me now, before moving on to unpack the internal logic this new epistemology, to show how this view is adopted among lab members.

Ikegami’s Zealots

What it means to be an artificial life researcher, Olaf tells me one day when I visit him at ELSI, is basically to keep an open attitude to the serendipitous, to serendipitous ideas and to surprises. In the words of Olaf, the main problem of the asphyxiating paradigm of “normal science”, a term he echoes following Ikegami, is that it fails, he tells me, to do the, “the ‘Elon Musk-kind-of-thing’”, by which he means

the lacking ability of scientists to think “big”. For Olaf, big scientific thinking - the opposite of normal science – is the ability to be extraordinary and to conduct unorthodox scientific research. But for Olaf, this “Elon-Musk-kind-of-thing” essentially involves building future humanity, future possibilities, and about making new scientific discoveries, in short, it is about being extraordinary and larger-than-life. However, whereas such “big” ideas, according to Olaf, are organized around technological advancements, for example, such as to establish the technological conditions of possibility to rocket humans into outer space, as Olaf says, to “become a Type III-kind-of-civilization, or at least Type II”⁶², they also reveal how Olaf thinks of artificial life as an enterprise beyond the confines of normal science. Olaf’s vision here, though, is highly exaggerated, and this exaggeration is not negative, but exactly what Olaf and the lab members are going for: they want to be pioneers of an unorthodox mode of science, who think “big” and believe they are destined to make a paradigm shift.

Olaf’s exaggerated techno-utopian vision, however, is not shared by all the lab members. Some lab members, I experienced, were more restrained in their claims, focusing less on building Kardashevian Type-civilizations. Yet, all of them still subscribed to a view that artificial life was working against convention and against dominant norms, for example, by envisioning how the training of neural networks to act “naturally” would do away with conventional AI, a way to break the dominant way of thinking about “intelligence” and “cognition”. All the lab members, in other words, in their own way felt that artificial life held the promise to circumvent and transform the world altogether, either by changing society, for example, by developing new technologies that change the way people think, or by changing science, for example, by establishing new paradigms. Yet, most visions, to be fair, were less fantastic than Olaf’s, but all the lab members marketed artificial life as an unorthodox and unconventional scientific enterprise with the potential to break the

⁶² Olaf was here specifically referring to the hypothetical Kardashev-scale, named after the Soviet astronomer Nikolai Kardashev in 1964, which regards energy consumption on a cosmic scale. The Kardashev-scale is essentially, although hypothetically, a method of measuring a civilization’s level of technological advancement based on the amount of energy they are able to utilize. The Kardashev-scale has three designated categories: 1) A Type I-Civilization, also called a “planetary civilization”, which can use and store all the energy available on its planet. 2) A Type II-Civilization, also called a “stellar civilization”, which can use and control energy at the scale of its solar system. And finally, 3) Type III-Civilization, also called a “galactic civilization”, which can control energy at the scale of its entire host galaxy.

conventions of normal science through novelty and innovation. Or, in other words, by thinking “big” and by being extraordinary.

Technological advancements, though, were always marketed with positive potentiality (Taussig et. al. 2013)⁶³, and as Olaf reveals, related to his observation that normal science fails at doing “the Elon Musk-kind-of-thing”. But while technological advancements are the arbiters of humanity’s future possibilities, Olaf is equally concerned about ways to do science in general. As he reports, “so, there are two ways to do science: you can do this experiment, like I have this hypothesis, and this specific hypothesis, and I know where I will get the results. This way allows for little progress, but it’s still very important for science. However, it is a way to do science, where you know where you are going from the beginning.” This is what Olaf calls “normal science”, following Ikegami. Olaf, however, also sometimes describes normal science as, “incremental science”, a sort of science working in chronological lockstep, but always in a linear and fixed way. “But Takashi and I,” Olaf continues, “we prefer to focus on surprises in science,” and making artificial life do the “Elon-Musk-kind-of-thing”, Olaf concludes, would be “nice”.

Now, many of the lab members are first and foremost in agreement that artificial life is a sort of “basic science”, one committed, they say, to ask “fundamental” and “scientific questions about life”. But like Olaf, they also feel compelled to think “big” and to carefully attend to “surprises” when asking these questions. But what is clear is that all of them generally subscribe to Ikegami’s bifurcation between good science and bad science. As Olaf further tells me, because the field focuses on “serendipitous ideas”, they should approach the subject matter accordingly, that is, by about making unplanned, surprising and fortunate discoveries, and thereby not plan everything in advance. This acknowledgement of the serendipitous, indeed this recognition that chance and incidence are productive things, I want to suggest, is part of Ikegami’s vision of the world. That is, the lab members align themselves and their ideas to his, to ideas of “emergence”, “normal science”, and the “serendipitous”. For example, in their eagerness to spot and/or invent something new, to capture something emergent, as cultural theorist Mitchell Whitelaw (2004) notes, is about catching, “something

⁶³ Read: chapter 2 on how technologies are tethered to dreams of betterment (cf. Lock & Nguyen 2010)

novel or unanticipated, something extra” (Whitelaw 2004:207). To many of the lab members this is the primary distinctive marker separating artificial life from normal science: that they actively, and perhaps strategically, seek to evade scientific orthodoxy in order to make cast themselves as insurgents or rebels.

One day during fieldwork, I asked Olaf how artificial life could do the “Elon-Musk-kind-of-thing” in practice. He replied, “I think it has something to do with this divide between scientific understandings, you know, as I told you, to do with this incremental science, where you know where you’re going.” Thus, to go back to Olaf’s notion of incremental science, which is mode of scientific research both synonymous or analogous with normal science that adds trivial additions to scientific knowledge, going from hypothesis to testing to result, it, “is a procedure where you know where you’re going from the start”. Or, more precisely, incremental science is where you know what you want to know from the beginning. “Artificial life is at the other extreme”, Olaf appends, “we know almost nothing about life. I mean, that’s not quite true because we know about a few properties, but we don’t know how to piece everything together yet. We don’t know about our chances of discovering life outside the Earth, but we know about some of its properties. But what artificial life does is maybe something like what Copernicus did at his time.” And this is the pinnacle of what it means to do the “Elon-Musk-kind-of-thing”. Allow me to explain.

The Renaissance-era mathematician and astronomer, Nicolaus Copernicus, who formulated a model of the universe that situated the Sun, rather than the Earth, at the center of the universe, according to Olaf, is the difference that made a difference to how we came to view ourselves, the world, and our place in it, and our knowledge of it. “It was unthinkable back then that his hypothesis would be right”, Olaf tells me, implying that Copernicus’ hypothesis was not only at the time controversial for the Catholic church, which feared that his model placed paradoxes at the heart of God’s creation, but also that it fundamentally constitutes what Olaf sees as a “breakthrough”. Copernicus’ model, according to Olaf, has simply, but radically, changed our understanding of the universe, and our place in it, and so too, he notes, can artificial life. But, as Olaf further notes, “Copernicus was not the only one with this idea. There were hundreds of similar ideas and most of them were false, but some

of them were about right, yet they didn't win the lottery," leading Olaf to conclude, "so, there are these serendipitous ideas in science anyway. And you have to go a little bit crazy, like Copernicus did. Many leaps in science looked like this, like Einstein, the fact that you would need another observer in your model and so on."⁶⁴

Olaf's story about Copernicus, of course, exposes a long-term dream quilted into the project of artificial life, which is shared among many of the lab members, who hope that they will someday, somehow revolutionize the world by changing our understandings of it. But Olaf's story also addresses and exposes that is dream is tethered to an ambition to make a paradigm change, just like Copernican astronomy did. In fact, I often heard lab members idolize popular scientists, who they associated with paradigm changes, such as Albert Einstein, Erwin Schrödinger, or Richard Feynman. Ikegami, for example, who is fond of Schrödinger, would often also refer to avant-garde artists, such as Shuji Terayama or pioneers such as the Wright Brothers – the American aviation pioneers, who generally credited with inventing, building, and flying the world's first successful motor-operated airplane. Imagine, Ikegami thinks together with Olaf and the rest of the lab, what it would be like if artificial life was credited with inventing and building the world's first artificial living being?

In the words of Olaf, artificial life should differ from normal science exactly by focusing on "surprises" and "serendipitous ideas", things normal science cannot grasp by clinging to convention, or rather, closer to Weber, by obeying the traditions of normal science. Stories such as Olaf's, I think, mirrors Ikegami's position at the lab, becoming symbolic of how the lab members are trained to cast themselves not only as insurgents and rebels, but also as intellectual pioneers and vanguards, poised to push beyond the limits of what they associate with normal science. In the process, Ikegami becomes a luminary, whose charismatic personality and suave ways of seeing and attending arguments constitute a new mode of legitimate rule. And so, this leads me back to how he defines his, "new epistemology of artificial life".

⁶⁴ On a side note here, this also vividly exemplifies how I experienced many of the lab members talking about the promises of artificial life. Many of them, like Olaf, drew direct parallels to famous, sometimes popular, accounts of "scientific breakthroughs", often celebrating the inspired, but misunderstood figure of the genius. One evening, out drinking, I enthusiastically spent a good 2-hours listening in to a discussion about Albert Einstein's and Elon Musk's many achievements.

A New Epistemology of Artificial Life: Between Science and Art

Ikegami, the son of a physicist, turned artist-scientist, began his career in molecular biology. “In college in the 1980s”, he tells me, “molecular biology was popular, so I considered that kind of academic research. But it was not the type of biology that I had anticipated. I wanted to understand life from different perspectives, so I reckoned that I needed to learn about physics and mathematics first.” In switching his attention to physics instead, Ikegami became enamored with the likes of Erwin Schrödinger and Richard Feynman. Both of them, felt at the time, had offered better and more fundamental accounts of life than any conventional biologist. However, while an admirer of physicists, for example such as Erwin Schrödinger, Ikegami also became enamored by the writings of figures such as Kenji Miyazawa, Osamu Dazai and Shuji Terayama⁶⁵. Writers such as these have strongly influenced Ikegami’s own thinking about life and the living world in ways that have become integral to how he imagines the project of artificial life at large. Indeed, Ikegami seeks to draw inspiration from both inside and outside science, in literature, music and film.

On a trip to Paris in 1998, the same year as he became interested in evolutionary robotics and physical awareness, Ikegami met artists such as Gabriel Orozco and Carsten Nicolai (Alva Noto)⁶⁶, an encounter that would irreversibly reshape his vision of science altogether. After this encounter, he realized, he tells me, that, “art is a totally different way to present ideas to people”, a form that offers, “a great opportunity of expression when there’s something I cannot simply explain with

⁶⁵ I want to add here an anecdote from my fieldwork, in which Ikegami and I were sharing our predilections for Osamu Dazai. In some of my interviews with Ikegami, we were sometimes lead astray into discussing some of Dazai’s works, namely his last novel *No Longer Human* (Ningen Shikkaku) from 1948. Dazai himself, a synecdoche for, and an icon of the perpetual attempt to grapple with life’s meaning, the meaning of being a human being, death, anxiety and the futility of existence, Dazai did not know how to be human. Many of Dazai’s late novels, for example, reflect a relentless self-abnegation, in which his protagonists experience complete estrangement, not only from human society, but also from *being* human, alienated from her own species, even existence itself. In *No Longer Human*, the novel’s protagonist, Oba Yozo, experiences a predominant feeling of stark terror at the incomprehensibility of other people around him – parents, teachers, friends, stranger and lovers. To cut a long story short, Ikegami and I often used authors, who we were both fond of, as metaphorical devices to discuss across domains science, art and technology.

⁶⁶ One evening in 2017, I had the privilege to join Ikegami at an art-science event with Carsten Nicolai, who met to discuss a bunch of topics ranging from life to music to the Deutsche Demokratische Republik (DDR).

words,” he says. “So, I realized that there are things happening in what we call the open everyday life that cannot be explained in terms of physics and mathematics.”

Thus, to go back to Ikegami’s notion that science makes a beautiful world, art is what captures, Ikegami suggests, that which “escapes rational logic” and those things that cannot be easily made sense of by the rationalities of normal science. Indeed, as Ikegami reports, art is essentially a path to make artificial life meet artistic and aesthetic ends, that is, to offer ways to express what scientific formalisms cannot. “I find in art,” he further tells me, “a great opportunity for expression when there’s something I cannot simply explain with words, so I’d like to understand life by creating it.” He reports,

we sometimes need art pieces and artwork to express, or to compensate for, what we cannot explain scientifically. So, if life is not simulated, but lived, art is what gives a sense of something scary, which is also a sense of something realistic, something you can express with art, something this is part of the messiness of the world. [...] You know, there’s a bunch of interesting mountains in Japan, rich animals and landscapes, and the mind is like that: there are many different minds, scientific minds, but no one is better than the other. The scientific mind is like a rainforest, different plants and animals. And this way of understanding the scientific mind is important, but it’s easy to get lost. Art, you cannot say one type of art is better than the other, but science tends to do that. It’s ok sometimes. But the imagination is becoming poorer.

Two things basically happen here: 1) Ikegami seeks to level the playing fields of science and art, as two distinct domains operating by different kernels of apodicticity, and 2) tells us that art pieces and artworks are propitious substitutes for expressing what cannot be explained scientifically. Art pieces, then, or rather by transforming artificial life systems to art pieces, offer a sort of “subtleness”, or subtle lifelikeness, which Ikegami believes is important to understand what life is. And this subtleness cannot necessarily be explained scientifically. “I think subtleness is quite important to understand what life is,” Ikegami goes on, “maybe I’m wrong, but that’s what I

concerned with: how to ‘pick up’ this subtleness, you know, to see if there’s a hint somewhere behind it all.”

Now, to pause, while it is clear, as already mentioned, that Ikegami’s style betrays a tension between the logical and rigorous figure of the scientist and the creative and spontaneous figure of the artist, he is not saying that science should turn into art. Rather, he maintains that art and science are distinct domains, but science can simply take from the domain of art new ways of expressing what cannot be properly expressed in scientific terms. That is, if science orders reality according to its own epistemic matrices and formalisms, art can compensate for what is not easily captured by science. It is therefore, in Ikegami’s words, this, “middle ground” between art and science, in which a new epistemology articulate for the field should be articulated, a liminal space where science makes active use of artistic expressions to convey what it cannot explain itself.

So, to go back to Ikegami’s notion that scientists keep believing in “mysterious things”, Ikegami is not saying that artists are necessarily any better at apprehending the “mysterious”. Rather, he is saying that scientists should seek some sort of middle ground between art and science to somehow tease out new meanings of life by keeping the objective gaze of the scientist and the subjective gaze of the artist. One person, who Ikegami thinks speaks eloquently of life from a sort of middle ground position, is his favorite physicist: Erwin Schrödinger. “Physicists like Schrödinger,” he tells me, “the father of quantum mechanics wanted to know why some matter becomes life, why some matter doesn’t, and what the distinction between the two is. So, when Schrödinger published his book *What is Life?* In 1944, it shook the world, and I think, out of many physicists, Schrödinger is the one person who wrote excellently of quantum mechanics, which inspired many people to think about life like Schrödinger did. Schrödinger said that ‘eating’ entropy is life, and when he presented the ‘aperiodic crystal’, a little broken crystal, as an actual origin of life, I think there were various ‘tips’ in it.”

During the latter half of the Second World War, the physicist Erwin Schrödinger, who was busy to understand the physics of life⁶⁷, made two auspicious proposals: The first he called *negentropy*, a concept used to capture what he saw as the remarkable ability of living systems not only to avoid the effects of entropy production, as dictated by the Second Law of Thermodynamics, but also to just the opposite, to increase organization: for an organism to maintain some structure, it must rid itself of the disorder that accompanies life-maintaining processes. The second proposal, notably of equal importance, is the idea that the hereditary mechanism that must exist so traits of individuals can be passed to offspring is more likely to be stored in what he called an “aperiodic crystal” – a structure with a specific but non-periodic arrangement of atoms, encoding information that guided the development of organisms. Molecules, Schrödinger believed, were too small and amorphous solids were too chaotic, so life’s structure had to be a sort of crystal (cf. Schrödinger 1944). (This proposal was made before the discovery of DNA). While the idea of the aperiodic crystal may inform Ikegami’s ideas about life, the point is here that Schrödinger also constitutes a role model for Ikegami in terms of taking a sort of middle ground position.

Thus, the “tips” Ikegami refers to are indicators that life more likely refers to the structure of an aperiodic crystal, a structure capable of harboring and transmitting the logic of heredity, which is legible as a sort of “code-script”⁶⁸ (cf. Helmreich 2016; Schrödinger 1944). The idea that life can be legible as a code-script or indeed thought of as information, Ikegami further implies, could not have been fulfilled without Schrödinger’s construal in the first place, and the “tips” in Schrödinger’s aperiodic crystal, in other words, are thereby pointers to the idea that life is more likely to unfold from the unified formal structure not necessarily holding DNA as a central basis for hereditary transmission and for life. These “tips”, although not especially artistic, or for that matter apprehended artistically, are what Ikegami refers to as

⁶⁷ The physics of life is a branch of theoretical physics that aims to survey how physics is relevant for biological applications. The field attempts to describe how physics is needed for understanding basic principles of biology, for example, the delicate balance between order and disorder in living systems, especially in describing how physics play a role in “high” biological functions, such as learning and thinking.

⁶⁸ Schrödinger’s account of life as an aperiodic crystal was later enlisted into models of the double helix of deoxyribonucleic acid (DNA), into informatic and cybernetic visions of vitality, and the decoding of the “genetic code.”

“shadows” or “deflections” of life, traces or signs that may somehow enable one to forge new meanings of life.

While well-versed in the great history of science, Ikegami looks to art and artistic expression as places of inspiration. But he does so to formulate alternative ways to make new meanings of life, which are not framed by scientific formalism. Indeed, a new epistemology of artificial life, then, should be one attuned to capture what Ikegami refers to as “deflections” or “shadows” of life - emergent qualities not easily captured by normal science. In practice, a new epistemology of artificial life, as Ikegami suggests, first involves 1) “constructing artificial life in the real world” in order to 2) be able to make “new meanings of life”, but based first and foremost on aesthetic judgements, i.e. the beholder’s *affective* and *embodied* responses to the artworks or objects in question, not on scientific formalism. What Ikegami means by Schrödinger is not the one should copy Schrödinger’s ideas on a one-to-one-basis, but rather to illustrate that Schrödinger, during his time, offered alternative views of life that were not at first accepted as “facts” (cf. Latour 1987). But unlike Schrödinger, however, Ikegami sees that “construction”, that is, the making of artificial life systems is the beginning of a series of events that might lead to better apprehend such “deflections” and thereby new meanings of life: i.e. one must build the things first and then make sense of them afterwards. To this end, Ikegami emphasizes that we should prioritize the beholder’s interpretation of the materiality of the medium over an evaluation of the artist/creator’s intentional deployment of that medium as the ground of a materialist expression (cf. Cronan 2013). This is to say, in other words, that Ikegami change the register of apprehension by which we understand life by synthesizing science with art, by taking a stance more closely aligned to postphenomenology and hermeneutics in order to “pick up”, as he says, the subtle emergences of life from the things they make.

Thus, learning to become sensitive to ways “deflections” of life may emerge through a sort of “affective formalism” - a formalism more closely aligned to postphenomenology, philosophy and art (Cronan 2013) – is critical to this epistemology of artificial life. Again, while Schrödinger was not considered an artist as such, according to Ikegami, he still dared to think beyond the paradigm of his time

and thereby to think about life in alternative ways. Indeed, Schrödinger was “ahead” of his time, his account of life as an aperiodic crystal would later be enlisted into model of DNA, into those cybernetic visions of vitality we still encounter today.

A new epistemology of artificial life, in this sense, is a formalism, or a critical framework, which is inextricably linked to the construction and materiality of artificial life systems. By constructing new artificial life systems, for example, such as the OEE-model of chapter 3 or, as we shall see later, androids, the effect on the beholder, generated by the material properties of such objects, including their form, color, and visual rhythm, should be privileged over cognitive questions ranging from the creator’s conscious or unconscious intent to the beholder’s affective identification with the artwork in question (cf. Cronan 2013). Yet, unlike affective formalism, Ikegami’s vision also necessitates that one attunes to the emergent *without* necessarily excluding a reading of the artist/creators’ intentions. After all, the intention behind artificial life systems is to make them “lifelike” and to make us think about life in new ways. Still, the point is that life’s meanings, according to Ikegami’s epistemology, may be somehow torqued out through the beholder’s interpretation of the materiality in question, which includes the material properties of an object, its form, color, or visual rhythm. In turn, Ikegami believes that this may splinter any preconceived or established definition of life exactly by making such definitions available for collective reinterpretation by the “masses”. In other words, and put differently, life’s definitions are not exclusively to be determined by science, nor to be framed by scientific formalisms, but rather by a new mode of apprehension that involves affective and embodied modes of knowing. To this end, negotiating and settling life’s ontological basis, then, is a question of “attuning to the emergent”, of individual and collective affective identifications and responses to the things they make at the lab, to heighten one’s sensitivity to how life emerges.

Attuning to the Emergent

One of the main issues relating study of life has historically been how to distinguish between attributes of life that are truly universal against attributes that solely hinge on

some particular history. Many of the lab members, including Ikegami, are aware of this problem. But in an attempt to untangle this complex, Ikegami tells me a comparative story about how two altogether different approaches in biology have led to the articulation of two relatively similar theories of life. But this time, Ikegami is not referring to Schrödinger, but to the prominent natural scientists Charles Darwin and Minakata Kumagusu. Both were scholars, Ikegami notes, who, like Schrödinger, offered new ways to think about life and the living, and both examples of how different paths can lead to similar results and vice versa. Indeed, seeing these two figures as pioneers of biology, especially due to their contribution to the life sciences by developing their respective theories of evolution, Ikegami's seeks to highlight and address the problematic and intricate relationship between scientific observation, inference, and theory-making. That is, in other words, Darwin and Kumagusu are central figures to how Ikegami seeks to articulate his new epistemology of artificial life and how this epistemology is embroiled and woven into the grand narrative of the Ikegami Lab. Indeed, more concretely, the story of Darwin and Kumagusu is at the heart of what it means to attune to the emergent.

In the early 1900s, the microbiologist Minakata Kumagusu (1867-1941), a scientific maverick and accomplished, though eccentric, scientist, made his claim to scientific fame in his study of slime molds (*myxomycetes* and *mycetozoa*): slimy, fungus-like things with strange lifecycles. With an interest in folklore and the supernatural, Kumagusu widely engaged in philosophical reflections on the relations between different kinds of knowledge and various kinds of phenomena. In his work, he conceptualized the combined set of worldly phenomena in a shape of a mandala, encompassed by the great mystery (*daifushigi*) of Dainichi Nyorai – the cosmic Buddha and central divinity in esoteric Buddhism. In this order, beings and entities encounter one another in a complex bundle of visible and invisible webs. Seeing vitality to unfold in such webs, Kumagusu distinguished between “wonders” belonging to what can be translated as abstract things (*koto*), concrete things (*mono*), the mind (*kokoro*), and reason (*kotowari*) (Minakata 1951). Above all, and more importantly in relation to Ikegami, Kumagusu recognized that the scientific search for the law of causality did not facilitate an understanding of all the world's relations, what he called *en* and *in* – or as a compound *innen* – considering the environment in terms of unstable networks of *innen*. Such networks, Kumagusu believed, were

generally shrouded in mystery. He writes,

Today's science grasps (or is expected to grasp) the riddles of causality. It comprehends causality or *in* (but not coincidence or *en*) ... *En* is what emerges out of the intertwining of one series of causes and effects with another. In order to grasp the total picture of the world, both cause and effect (*in*) and their interrelationships (*en*) should be understood" (Kumagusu 1971:391-92).

For Kumagusu, reasons, relations, and entities in the domain of *daifushigi* existed, but their mode of existence evaded, he thought, the scope of modern science, which typically looked only for laws of causality, what he called *in*. To translate this into Ikegami Lab vernacular, modern science largely fails to tackle and comprehend *en*, looking instead only for *in*. Rather than studying causality, Kumagusu contended, scientists should focus instead on chance or co-incidence as pivotal to better understand the ontology of things, which meant cultivating one's perceptual abilities to apprehend *en*, that is, by developing what he called *tact* (Kumagusu 1971).

For modern science, lack of observability has for long called upon methodological anxieties, as unobservable or invisible entities, say, such as spirits or ghosts, slip away not only from the installed systems of representation employed by scientists but also scientific modes of reasoning. Indeed, strict empiricist or positivist methods for encountering such entities either ignore them, relegate them to the realm of metaphysics or superstition, or they are simply inadequate. But Kumagusu's view of the "wondrous" not only draws indirect parallels to artificial life's notion of "emergence", as that, Mitchell Whitelaw (2004) writes, which "refers to something novel or unanticipated, something extra" (Whitelaw 2004:208), but it also marks his acknowledgement of the multiple bodies and the environments of the world, which are so varied that they can neither be tamed or captured by the scientific descriptions of modern science. Nor can they easily be grasped, Kumagusu said, by lived experience in its conventional phenomenological sense.

On Kumagusu's view, entities are enmeshed in *en* with the potential for evoking and event affecting a person or a thing. Kumagusu writes,

Without cause (*in*), there is no effect (*ga*). And if the cause is different,

then the effect also becomes different. *En* means that as one series of cause and effect (*inga*) continues, it is infiltrated by another series. The influence of *en* is called an occurrence (*ki*) ... Therefore, various series of cause and effect continue on the body. At any moment, we encounter innumerable *en*. They can make occurrences happen, depending on how one minds them or how they touch one's body. Because of these occurrences, some causes and effects that were continuous until now move out of their orbit, while others return to their original path. (Kumagusu 1971:391)

Thus, as Kumagusu suggests, it all hinges on the prospect of learning to be affected within the web. Events occurring beyond scientific cognition and description are arrested neither in the split between belief and disbelief, nor between existence and non-existence. Rather, as Kumagusu proposed, the occurrence (or “emergence”, again, to stick with artificial life nomenclature) of events depends on learning to be affected by different entities and relations within the webs of *en*.

Now, to go back to Kumagusu's slime mold, which is neither living nor dead, but perhaps best characterized as a quasi-living thing, like viruses, he saw that it changed from being a moving amoeba to small fungus-like bodies in a very short amount of time. According to Kumagusu, from observing the dynamic life cycle of slime molds, the criteria of life and death in general is not as simple as one might expect because in the transformation of *myxomycete*, living cells and dead cells interact with each other in complicated ways. This, in turn, makes it difficult to draw a clear-cut line between life and death of either one cell or one individual life. To be able to notice slime molds, then, became a question of tact, as Kumagusu saw in slime molds the active interfaces between the thing and its environment. Moreover, slime molds were objects, one might say, embodying the continuity between life and death in the sense that they manifested, in their way of being in the world, a continuity between different orders or scales of the living, from the microbial level to the ecological level. Thus, thinking *with* slime molds, Kumagusu formulated a universal theory of life's total connectivity from the smaller anecdotal vital signs exuded by *myxomycete*.

In parallel, although about sixty years prior to Kumagusu's development of his biological theory of life, in 1831, natural scientist Charles Darwin had been invited

onboard the HMS Beagle on route to conduct a hydrographic survey of the southern part of the South American coast. For five years, Darwin surveyed the South American coastlines, coming across the Galápagos islands. Here, he filled dozens of notebooks with careful observations on animals and plants and collected thousands of specimens, which he then crated home to his native England for further study. Returning from his sea voyage, Darwin argued inductively from data and specimens he and other crewmembers had collected, that a process of descent with modification could be inferred as the force giving form to organisms. That is, form that was transmitted down generations. In his work from 1859, *On the Origin of Species*, based on his experiences in the South Americas, Darwin speculated, he wrote, that “probably all organic beings which have ever lived on this earth have descended from some a single primordial form, into which life was first breathed” (Darwin in Beer 2000:48).

In other words, Darwin offered an account in part from his collection of specimens⁶⁹ of how living form materialized out of what could be environmental or ecological dynamics, by which his theory of evolution by natural selection encompasses that all life is related and has descended from a common ancestor: birds, bananas, fish and flowers. In short, life emerges from nonlife, and complex organisms naturally evolve from simple ancestors over time. As random genetic mutations occur within an organism’s genetic code, only the beneficial mutations are preserved in the service of survival, the process Darwin called “natural selection”. The beneficial genetic mutations are passed on to the next generation and so on, over time, accumulating and resulting in an entirely different organism, which may not be considered a variation of the original, but altogether different in *kind*.

Now, Ikegami’s science history lesson here is directly interwoven with the ambitions he has for his field, and particularly serving his interest in defining the contours of a new epistemology for his field. Ikegami’s reference to Darwin and Kumagusu exposes not only his historical awareness about some of the issues relating to scientific observation and the prospects of making theoretical knowledge claims about

⁶⁹ Some people point to “Darwin’s finches” – including various finch species, such as the warbler finch, sharp-beaked finch, ground finch, and common cactus finch - as symbols of evolution in the Galapagos islands. However, Darwin, apparently, hardly mentioned finches in his later writings. But like Kumagusu’s slime molds, finches were among the species collected by Darwin to formulate his theory of evolution among mockingbirds and tortoises.

the world, which are based in practices of empirical observation. It also exposes, I think, his ability to marshal “great scientists” to serve his cause and to bolster his position as a leading figure at the lab. The story of Darwin and Kumagusu, who, although in slightly ways attempt to determine life’s form from its matter, provide the resources Ikegami needs for building his own epistemology. Like Kumagusu, who saw in slime molds the dynamics of life, so too must artificial life be engaged in strained intellectual labor of making theoretical inferences from empirical phenomena they make. As such, Ikegami sees that this work of inference can also be based on the construction of artificial life in the real world, but it still requires one to attune to the emergent. Or rather, to follow Kumagusu’s argument, it requires of someone the prospect of learning to be affected within the web. The difference, however, is that this web is spun by artificial life researchers themselves. As such, one thing I believe Ikegami is also pinpointing in telling this parallel story of Darwin and Kumagusu, is their mutually shared interest in locating life’s *form*, here understood as a sort of empty signifier, which can be imbued with *meaning*. However, Ikegami, in contrast to Kumagusu and Darwin, seeks to do so from a very different, perhaps even mutually exclusive, set of proclivities and conditions of possibility, but his story ultimately concedes, I believe, that his epistemology of artificial life is a sort of intellectual continuation of Kumagusu’s and Darwin’s projects at large.

The artificial life researchers at the Ikegami Lab, needless to say, are not committed to explore either slime molds or to collect specimens like Darwin and Kumagusu, but Ikegami seems to imply, through their story, that life, or at least a theory of life, might be articulated in a somewhat similar fashion. Not from biological substance, but from the artificially-created things they make at the lab. Or, as he says, “either through computational simulation, robot manipulation, or chemical experiment, the exploration of potential behavioral patterns is necessary to build a new natural history of artificial life.” Building a new natural history of artificial life, oxymoronic as it may seem, Ikegami suggests, is about establishing the correct conditions of possibility for doing so. Thus, if, for Darwin, the “forms” at stake in his theory of evolution materialize in “species” or “organisms”, that is, as durable but changeable genealogical kinds, or for Kumagusu, the “forms” at stake in his mandala theory of life materialize in slime molds, it suggests that form is essentially crystallized with respect to two altogether different kinds of causal ontologies. Form, here, then

suggests, as art historian Henri Focillon (1989) reports, that it is, “surrounded by a certain aura; although it is our most strict definition of space, it also suggests to us the existence of other forms.” (Focillon 1989:34). In other words, life’s form, as pertaining to Darwin and Kumagusu, is crystallized with respect to two different *fields of possibility*, suggesting the possibility of other forms: if both of their theories of life and evolution were accounts of how living form materializes out of environmental or ecological dynamics, they were based nonetheless in different logical frames. Now, once one realizes that Ikegami’s story here serves a particular purpose, namely to bolster the coherency and validity of Ikegami’s epistemology, including his own position at the lab and in a broader intellectual landscape, one may also notice that this story aligns to the previously mentioned ideas about the adjacent possible and ideas about open-ended evolution.

This is exactly what Ikegami is going for here: to make his stories fit to his own project, in which he largely gestures towards making his own field of possibility, an effort, by which he and his team of researchers may seek anew to abstract other possible forms and meanings of life. Ikegami’s story, then, is not only a narrative way to tie artificial life into the wider history of science, technology and biology, as we saw some of the contours of in chapter 2, but it is also a *strategic* way to extend inquiries and amplify explanations of living form by virtue of modifying how one infers not only from observation, but also from construction, new meanings of life. Indeed, the conditions of possibility for identifying life’s *possible* forms, and *possible* meanings are based on the construction of artificial life systems, by building them piece by piece, from synthetic materials. But it is important to keep in mind that Ikegami is at the center of this epistemology; he is, after all, the one who controls the overall narrative of the lab. Thus, if Darwin and Kumagusu were writing the natural history of biological life, Ikegami promises to write the natural history of artificial life by constructing it⁷⁰. Now, in the final section of this chapter, I want to show Ikegami

⁷⁰ On a side note, this also relates to biologist and mathematician D’arcy Wentworth Thompson (1917), who in his work *On Growth and Form*, argued that the shape of organisms was both constrained and shaped by a sort of mathematics or geometry of nature (Thompson 1917). Thompson drew heavily on the language of physics and mathematics to make sense of organismic morphology, believing that embryology, for example, like his successor Schrödinger, could learn much from studying crystal growth patterns (Thompson 1917). Now, if Thompson claimed that morphology arose through mechanical interactions with an organism’s environment, in promoting the use of algebraic and geometric formalisms to account for living form, then Ikegami agrees. But what happens to such claims in the advent of new technoscientific practices, in which artificial life researchers are directly

imagines how this new epistemology is supposed to be pushed into practice.

A Real World Laboratory of Play

To illustrate how Ikegami seeks to push this new epistemology into practice, the work of artist Shuji Terayama (1935-1983) makes for an appropriate facsimile. Indeed, since Ikegami's new epistemology is a "middle ground" between art and science, Terayama's work may highlight how artistic approaches and performances are central to Ikegami's thinking about artificial life. During fieldwork, Ikegami often referred to Terayama's experimental feature film, *Throw Away Your Books, Rally in the Streets* [Sho o suteyo machi e deyou] (1971) - a piece of agitprop about an angst-ridden teenager taking to the streets to escape from his dysfunctional family - as being highly influential to his work. While the film is commonly considered to be a metaphor for Japan's descent into crude materialism, following the Second World War, Ikegami's construal of the film is that it epitomizes that the world happens "out there" in "the streets", in the "real world". To the viewer, *Throw Away Your Books, Rally in the Streets* opens with an agonizingly protracted black screen carried by a subtle soundscape, and just as the viewer begins to think there is something wrong with the video, a young man dressed in a trench coat appears and berates the viewer's idiocy for having fallen for the trick: what are we doing here, sitting watching this film waiting for something to happen when the real action is, and always has been, out in the streets? Hanging around will not do us any good, the viewer is told, a signal, Ikegami thinks, which emblazons the fact that the real world has always happened outside the confines of the laboratory.

engaged in constructing, in a synthetic way, living form, when "organismic morphology" is at the hands of humans? Might this amount to say that social, cultural and affective practices, too, may constitute living form? If we follow the lab members at the Ikegami Lab, the answer would be yes, insofar you must construct the things you want to understand. Moreover, though, Ikegami adds that living form may equally be accounted for, not simply by employing algebraic and geometric formalisms (note that these are instances of what Ikegami regards as normal science formalisms), but by viewing living form through a sort of affective formalism, through art, through the body of an internal observer, a view that holds the observers' affective response to living form, whether generated by the material properties of an object, its form, color, or visual rhythm, as integral to its *meaning*.

Terayama's film, however, is to Ikegami nothing more than a metaphor. But there are, I think, many substantive similarities between Ikegami and Terayama in the way they both seek to approach vexing questions about reality and how one should be committed to that reality. And as such, Ikegami's reference to Terayama is no coincidence, but an active attempt, I think, to mirror his his vision of artificial life and what he hopes to achieve by it. After all, Terayama and Ikegami agree that the "real world" is outside the theater and outside the laboratory, respectively, and it is to this world we should be committed, both when doing art but also when doing science.

Around the time when Ikegami was born, in the dying days of the 1960s-youth rebellion, an era when Japan's underground was reaching its peak, Terayama was a central figure in creative expression, shuffling the liminal spaces between materiality, imagination, fact and fiction. Many years later, in our contemporary moment, Ikegami now seeks to make artificial life meet aesthetic ends, hoping to create things that capture people's imaginations. Ikegami, as many of the lab members say, is a "generalist", one, "who does everything Alife", but Terayama, too, was also a rounder: a poet, playwright, novelist, photographer, sports commentator and filmmaker. Now, for Ikegami, Terayama is not only a role model, but he is one of the most innovative figures of the 1960s and 1970s Japanese avant-garde, most vividly expressed in his fierce attempts to rupture and dissolve facades, surfaces, faces, illusions and identities. In Terayama's piece, *The Reading Machine* [Shokenki] (1977), for example, a Borgesian satire on knowledge and technology, bibliophilic desires lead to the construction of a pedal-powered reading machine, depicting a scene where the camera lingers on an image of a man crawling through a book. Or, in *Laura* [Rora] (1974), where Terayama's attention to surfaces culminates in the consummation between performer and spectator, as three strippers hurl insults at the audience only to lure one of them to literally enter the screen, from which he emerges clutching his torn clothes after being stripped and mauled on celluloid. Come here, the strippers say, come into the screen. And it is exactly this same sort of enticing and boundary-rupturing qualities that Ikegami encourages his lab members to build into the things they are constructing at the lab. Indeed, these are vital components to his epistemology of artificial life.

But there are other quite striking similarities between Ikegami and Terayama in the way Ikegami construes Terayama's artistic performances in daily life. Terayama saw conventional theater as bourgeoisie and elitist, which animated him to return to do something more impromptu, honest, and unorthodox, what he called "theater for the masses". For example, in his most ambitious work to date, called *Knock*, Terayama staged a 30-hour live performance through the backstreets of Tokyo's Suginami ward. At 3 p.m. on April 19, 1975, an assembled audience, equipped with maps, was guided through 19 performances around Suginami, some of which were rehearsed, while others were impromptu. But all the performances required the audience's participation, demanding of them to become part of the "play" itself. As such, Terayama was a "choreographer of the masses", as he went into public life (a domain he saw as his "laboratory of play"), turning the street into stage. Similarly, Ikegami strives to "bring artificial life to the real world" in a similar fashion, to turn the "real world" into his own "laboratory of play", however, imagining the real world, still, as a lived reality, which may potentially also be dangerous. But this is part of the catch: anything can happen in the real world.

To further bolster this point, Ikegami refers to yet another artist. In 1982, during Nam June Paik's (1932-2006) show *Becoming Robot* at the Whitney Museum, New York City, Robot K-456, named for Mozart's *Piano Concerto No. 18 in B-Flat major, K.456*, was run over by a car. What Paik saw as the catastrophe of technology in the twentieth century, Ikegami sees as the epitome of what it means to bring "artificial life to the real world". In the words of Ikegami, "I base some of my theories on the work of the artist Nam June Paik. You know, usually, you build a robot in a laboratory-setting and you experiment on it there. But Paik took the robot to the city. And in the city the robot was hit by a car, and so it was the first robot to ever have been involved in a traffic accident." That K-456 was the first machine to become involved in a traffic accident, Ikegami quips, is "what happens in the real world!"

Now, if the real world can be made into a "laboratory of play", at least in theory, it also means that "play" and "performance" are important elements of knowledge production and what it means to infer new meanings of life. If Ikegami believes that life is somehow apprehensible, and something to be made sense of, on some affective

register, “play” is also about learning to master how to “sense” vitality in a playful, curious and perhaps naïve way, indeed how to cultivate and hone one’s perceptual abilities. That is, “play” is here about attuning to what “emerges” beyond the technical specifications of any artificial system, which includes apprenticeship in sensory, auditory and tactile technique. Thus, constructing new artificial systems is not simply about devising a new object solely for the sake of doing so or for testing some technical hypotheses; it is also about constructing physical, embodied systems, such as robots, which, as Ikegami tells me, “are able to interact with their environment in order to create new human-machine interfaces” in order to be somehow personally “affected”. Play, then, rather than being the act of engaging in activities of recreation or enjoyment - although Ikegami wants their artificial systems to “exciting”, “strange”, and “weird” in the sense that he wants them to be affective objects that impose upon observers – is also here serving a serious and practical purpose, namely to generate new knowledge and new meanings of life.

And it is exactly the making of new human-machine interfaces, as Ikegami implies, which is a basis for teasing out some new meaning of life, he says, between the “solvable” and the “unsolvable” dimension of reality. There are, Ikegami holds, things in the real world, which can be solved by normal science, as Kuhn also suggests, by the usual sort of “puzzle-solving” (Kuhn 1962). However, there are also things, such as the irrational, the unconscious, why people do as they do; why they become criminals, friends, or enemies of one another, and so on, which cannot be explained by some mathematical equation. And this is despite of scientific attempts to do so: computer scientists, for example, write predictive algorithms seeking to anticipate behavioral or economic changes, but such things cannot be easily predicted, Ikegami thinks, nor be can they be reduced to algorithmic logics. Ikegami reports,

Normal science has been trying to objectify subjectivity, but it’s difficult, right? It’s not something easily quantified or measured. But if you do, it doesn’t tell you anything about it. Even if science one day explains all the riddles of DNA or neurons, the question ‘what is life?’ will probably never be answered. Instead of trying to find answers to impossible questions, science should be about thinking in the gap between the

solvable and unsolvable parts. There's always something that escapes rational logic. The world is beyond logic.

Thus, the world can be apprehended between science and art, between what Ikegami associates with the rational and the irrational, the logical and the illogical. Crudely put, there are things that can be known by science and there are things that cannot be known by science, which is why we need to think “beyond logic”. Thus, Ikegami encourages, or persuades, the lab members to think beyond the established logics of normal science, in the “gaps”, what Olaf thinks of as outside incremental science, demonstrating how this epistemology proliferates among lab members. It is, in other words, a formalism by which to think in between the “solvable” and “unsolvable” parts, between the known and the unknown, in turn constituting a sort of creed, which is both authority and charismatically communicated by Ikegami to his followers in ways that makes it slip into the imaginary world the lab members. As Olaf also testifies, this is about thinking “big”, about thinking against normal science, and more importantly, I argue, about constructing a relatively coherent set of beliefs, norms and ideas, by which the lab members are invited to see the world.

Ikegami's epistemology may not be an airtight, impermeable, and thoroughly consistent way of seeing the world, but it nevertheless offers epistemological guidance to the Ikegami Lab at large. And this epistemology, I argue, conveniently aligns to how Ikegami sees reality, that is, to how he makes ontological claims to reality, as we saw in the previous chapter 4. As such, Ikegami's ontoepistemological constitutes a charismatically-certified paradigm, which is summed up in my term Ikegamianism, informs the lab members' ambition to construct artificial life in the real world. Thus, I argue, on the basis of chapter 4 and 5, that Ikegamianism challenges the paradigm of normal science *and* offers philosophical, metaphysical, ontological and epistemological guidance to the lab members.

Now, in the final chapter, I want to show how Ikegamianism - a shorthand for the charismatically-certified ontoepistemological framework that informs much of their work at the lab - is indeed a new, nascent paradigm, which materializes *through* the actual work of constructing artificial life in the real world. That is, in short, in the next

chapter, I want to show how Ikegamianism is given material expression through what I call *parallax machines*.

6

PARALLAX MACHINES



Alter. Photo courtesy of: author.

Introduction: Parallaxis

In the spacious lobby at The National Museum of Emerging Science and Innovation (The Miraikan) - colloquially known as the “future museum” - located on the artificial island of Odaiba in one of Tokyo’s central districts, a crowd of people await the opening of the anthropoid opera *Scary Beauty* – the world’s first “android opera” featuring *Alter*, an upper-body android. *Alter*, with its porcelain-white face and mechanical body, is the first “real world” android to “autonomously” conduct a human orchestra. The show begins. On stage, looming in shadows, *Alter*’s white face shimmers and sways slowly from side to side. Spotlights flicker to illuminate the stage, as the show’s human composer, Keiichiro Shibuya, a friend of Ikegami, enters the stage. Visible from the platform below, where the crowd is seated, *Alter*’s shiny metallic body and matte silicone-skinned face reflect beams of red, blue and purple cutting through the darkness.

A deep electronic and ambient sound fills the room to *Alter*’s high-pitched ghostly voice. As the human orchestra tunes in, *Alter* turns towards them and raises its arms. Two adjacent screens on either side of the stage display the names authors William S. Burroughs, Ludwig Wittgenstein, Yukio Mishima and Michel Houellebecq, blurs of Burroughs’ cut-up texts, white on black, accompanying the tunes of Keiichiro’s keyboard, the symphonic sounds of the orchestra, and *Alter*’s synthetic voice. The cacophony of noise slowly morphs into a main theme, a simple piano melody that builds up, adding more and more instruments. Meanwhile, Houellebecq’s *The Possibility of an Island* take shape of lyrics, which are transduced by *Alter*’s voice into a rather melancholic chorus. The music reaches a crescendo as *Alter*’s gesticulations urge the musicians on before ending the song on a long note. The play ends in a roaring applause and deep silence.

In this final chapter, I explore how the anthropoid *Scary Beauty* becomes a material expression and culmination of the technical, philosophical, epistemological and ontological work of the Ikegami Lab. Namely, I query how Ikegamianism is translated into practice in a “real world” setting at the cultural event of *Scary Beauty*, a new space of “open” human-machine interface, by which we are invited, alongside

the lab members and audiences present the event, to tease out some new meanings of life. Indeed, *Scary Beauty*, I want to show, is a vivid display of how Ikegami seeks to make artificial life meet aesthetic ends and the epitome of what it means to construct artificial life in the real world.

In what follows, I want to describe *Scary Beauty*, not simply as a specific type of human-machine interface, but more precisely as a space of a specific sort of “collaborative sensing practice”, following scholars of sensing Jennifer Gabrys and Helen Pritchard (2018). Considering *Scary Beauty* as a mode of collaborative sensing practices, I want to zero in on how newly constructed, embodied artificial systems, such as Alter, are material instantiations of what I call *parallax machines* – abstract and material machines that materialize Ikegamianism *and* offer what I call a *parallax view of life*, by which “life” is not easily incorporated into a fixed set of significance, following philosopher Brian Massumi (1995), which is to say that life is “not semantically or semiotically ordered”. Because Alter is itself ambiguous, both in terms of its physical design and in terms of its behaviors and actions, it functions, I argue, as a parallax machine, working both to embody how artificial life researchers at the Ikegami Lab work and think *and* to connect, without resolving, what is normally “indexed as separate” (Massumi 1995:85). In turn, I argue that this offers a parallax view of life, with “life” remaining something emergent, something generic, always-already imperiled, or nearly there, yet still manifestly concrete, physical and tactile. That is, a view that situates “life” in between many different indexical registers, between the real and the unreal, the biological and the artificial, the artistic and the scientific, the mechanical and the organic, the human and the nonhuman, but without resolving them. And this is exactly the point of their artificial systems: they keep them unresolved, infixed, and, I want to suggest, ontologically indeterminate.

First, following scholars of sensing Jennifer Gabrys and Helen Pritchard (2018), I consider *Scary Beauty* an instance of what they call “collaborative sensing practices”, which refer to, “the ways in which sensing and practice emerge, take hold, and form attachments across environmental, material, political and aesthetic concerns, subjects and milieus” (Gabrys & Pritchard 2018:394). In their revamping of what sensing practices mean, Gabrys and Pritchard do not speak of such practices as exclusively

human. Rather, sensing practices are intrinsically a collaborative undertaking, which is what they term “collaborative sensing [...] far removed from the Cartesian brain in a vat,” to instead denote “the ways in which shared worlds are felt, sustained and even created” (Gabrys & Pritchard 2018:395).

Thus, by approaching *Scary Beauty* as a specific human-machine-instantiated mode of collaborative sensing practices, then, I attend not only to the human senses as such, or to the senses as a human point of mediation, but also to the ways in which “sensing-as-practice” (cf. Gabrys & Pritchard 2018) resonate with particular entities and relations, namely machinic and human. That is, *Scary Beauty*, as a specific human-machine interface, becomes a merging of “an assumed human-centered set of perceiving and decoding practices” and those of “extended entities, technologies and environments of sense” (Gabrys & Pritchard 2018:395). In short, I read the “cultural” event of *Scary Beauty* as an instance of how the lab members, and audiences, seek to tease out new meanings of life in new human-machine interfaces, where “life” emerges in a regime of interactivity (cf. Penny 1996). As such, *Scary Beauty* brings aesthetic and material fruition to the ontoepistemological abstraction I call Ikegamianism, namely because it is rooted in Ikegami’s understanding of reality and his own self-articulated epistemology.

Second, I add to this reading the analytic concept of parallax machines to order to capture how Alter embodies many elements of Ikegamianism, in part, by becoming a material and abstract machinic entity that materializes what Ikegami and the lab members understand, and seek to understand, about life, namely that “life is an emergent phenomenon [...] emerging in masse data flows”. But, as I will argue, parallax machines do more than simply materialize Ikegamianism; they also provide a new perspective on life, what I call a *parallax view of life*. So, parallax machines are *material* simply because they are substantively tactile and physical (after all, Alter is a technical assemblage of bits and pieces of synthetic materials), and *abstract* simply because they embody Ikegamianism, because they are theoretical models of artificial life that are capable of performing input-output operations and manipulating symbols, e.g. information, (after all, Alter is machine akin to Turing’s abstract machines in its capacity to perform input-output operations based in its sensor system and internal

systems), and because they offer new perspectives on life. And so, Alter does a lot of work for Ikegami and his team of researchers: parallax machines are epistemic things that serve to destabilize biologically-established understandings of life (cf. Rheinberger 1997); machinic objects for building new viable instantiations of human-machine interfaces in the sense of creating new modes of relatedness, which are spun across a range of categories normally indexed as separate; and social tools for building alternative narratives of life. Alter, then, as a parallax machine, invites audiences and lab members alike, to take parallax view of life – a view that sees life in a parallax as simultaneously artificial and natural – which is made possible exactly *because* Alter is deliberately constructed to be indeterminate and incomplete, putting together two seemingly incompatible notions of life on the same level.

Alter, in short, both materializes the sort of thinking at the Ikegami Lab (Ikegamianism) *and* stimulates a parallax view of life in the sense that it realizes what philosopher Immanuel Kant called “transcendental illusion” (cf. Karatani 2003) – the illusion of being able to use the same language for phenomena, which are mutually untranslatable and can thereby only be grasped in a kind of parallax view. Thus, I am inspired to use the phenomenon of “parallax” – a word from ancient Greek *parallaxis*, meaning “alternation” that points to a displacement or difference in the apparent position of an object viewed along two different lines of sight – partly from the observation that modern theory is cluttered with modes of parallax and partly because Alter is an ambiguous entity that cannot easily be grasped by those established biological interpretive frames by which life is conventionally apprehended, nor by normal science. From modern theory, quantum physics, for example, vacillates on the parallax view of the wave-particle duality, while neurobiology vacillates on the parallax view that if we look behind the face into the skull, we find nothing but piles of grey matter, neurobiology being a science that seeks to make a “third-person” account of our “first-person” experience. These are, among others, parallaxes that mark the irreducible gap between the phenomenal experience of reality and its scientific explanations. Artificial life in general, and Ikegamianism in particular, now vacillate on the parallax view of the artificial-biological duality, and this is exactly what makes it fascinating to many observers.

To this end, I argue that Alter is at once a materialization Ikegamianism, if not Ikegami himself, *and* an invitation to take a parallax view of life by allowing one shift one's perspective on life without resolving into synthesis or by resorting to any fixed set of significance exactly by virtue of occupying a space, where there is no rapport between the artificial and biological. Yet, still, in this space, these categories are closely connected, perhaps even identical in a way, as if they are on the opposed sides of a Moebius strip. And this is basically what I mean by a parallax view of life. Alter, then, *works* as a parallax machine exactly because it occupies this tension.

Now, I will begin by making a description of Alter in more detail before moving on to show how Alter comes to function as a parallax machine that materializes Ikegamianism and how it participates in collaborative sensing practices to offer a parallax view of life.

Alter

Named in analogy to the human mind (alternative mind), the physical appearance of Alter reveals a shimmering porcelain-masked face with an open scalp exposing that it is comprised of mechanical parts and bundled circuitries. Its upper-exoskeletal body is only partially coated in silicone skin, which leaves its metallic parts overtly visible. As such, its physical and exterior appearance alone immediately confirms to the onlooker that it is not made of flesh or organic tissue, appearing, to the naked senses at least, as a humanoid form based on outward resemblance to a human body. But the lab members, however, say that the physical design of Alter is supposed to appear to onlookers, not as “humanlike”, but as “neutral” in the sense that it is supposed to “appear ageless, genderless and uncultured”. To this end, they tell me that Alter is a sort of “non-cultivated” or “non-cultured” being, a not-yet-cultured, generic being, a tabula rasa. This notion that Alter is “uncultured”, needless to say, strikes at the heart of long-standing anthropological inquiries about what it means to be with or without culture (cf. Geertz 1973).

Now, to Ikegami and the lab members, one of the main ambitions with Alter is tethered to hopes that such an “uncultured”, or yet-to-be-cultivated entity might

potentially be “trained” – i.e. cultivated *into* the real world⁷¹ - through “feeding” on “massive data flows”. As Ikegami notes, “Alter does not try to stop the massive data flows, but tries to use them to its advantage”, which means that Alter is, in a sense, imagined to emerge, “come-into-being,” or perhaps “come-of-age”, if you will, by and through interactions with the real world. By “autonomously” feeding on, and making use of, the available information in its immediate surround, the lab members hope to make Alter’s operations independent from any sort of remote control by a (human) operator, which may in turn offer that it “self-organizes” on the basis of giving and taking information from the environment⁷². In this very first design ambition, Alter already embodies some of the theories that the lab members associate with the living, namely the notion of autopoiesis, which we encountered earlier on in this thesis. But more significantly, harking back to chapter 2, Alter is the very instantiation of what Ikegami means by his notion of Singularity, as the point where technologies, “escape us”. Indeed, Ikegami hopes to construct a machine that might not surpass humans, but escape us exactly by being *different* from us, *not* by being smarter or more intelligent⁷³.

Thus, with a potential to be trained and cultivated, Alter is considered to be in a primitive (evolutionary) stage. And insofar it is named not only in analogy, but in opposition to, the human mind, its design, Ikegami asserts, is to be evaluated based neither on its physical fidelity to the human bodily form, nor its resemblance or likening to the human mind. Rather, it is supposed to be perceived and assessed exactly by virtue of what it *is*: as a sort of “alternative mind”, a mind radically different from the “human mind”, indeed a sort of being that is thoroughly artificial, not to be mistaken for any organic living form. In this respect, the idea is that Alter

⁷¹ Here, their idea of being “cultivated” is more closely aligned to how chemists, for example, think of the process of “cultivation”. In chemistry, “uncultivable” microorganisms have been shown to grow in “pure culture” if properly provided with the chemical components of their “natural environment”. In other words, cultivation means doing laboratory work, a process different from “naturalization”. In the field of anthropology, Clifford Geertz (1973) suggests that, “we [humans] are, in sum, incomplete or unfinished animals who complete or finish ourselves through culture” (Geertz 1973:49), so that, “to act, we were forced, in turn, to rely more and more heavily on cultural sources- the accumulated fund of significant symbols (Geertz 1973:49).

⁷² Read: autopoiesis (cf. Varela et.al. 1974).

⁷³ Here, Ikegami differs from Kurzweil in making clear that machinic intelligence might be altogether different from human intelligence, and thus machinic intelligence should not be evaluated in relation to, or against, human intelligence. They are, Ikegami holds, two radically different things. Also, another point of difference is that unlike Kurzweil, Ikegami is not seeking to “upload” human consciousness in machines or digital space. Rather, Ikegami seeks to make an entirely new form of “consciousness”.

may embody an entirely new form of mind, or become an entirely new life form altogether, which makes it imaginable as an immanently tactile and embodied artificial life form. But above all, and to be sure, Alter is explicitly described by the lab members to be radically different in kind from any other life form we may know of, the point being that Alter should be evaluated, assessed and made sense of as an alternative to biological organisms.

As to why Alter has a human-like body, then, is not only because it has to be able, according to the lab members, to “participate in the same bodily space as human beings”, but also simply because it imposes new technical challenges pertaining to making more fluid “lifelike” movements in general. As Lana explains,

The goal when the Alter-project started ... Well, if we look at the Ishiguro Lab [Osaka University], and their robots. When they don't move, you might mistake them for a person. But as soon as they start moving, you see that they are robots because their movement is so weird. So, our goal was to remedy that, to not by making the movements weird, but because there had to be a way for robots to move in ways that looks natural to us, even if it's not a humanlike way of moving.⁷⁴

To “remedy” this, then, as Lana notes, Alter is technically composed of 42 movable air actuator joints with integrated potentiometers tethered to, and powered by, a set of large air compressors, which are operated by an advanced operating system called a Geminoid server⁷⁵. Air, the invisible gaseous substance, in other words, is one of the keys to make Alter move more fluidly and organically, one might say, rendering its movements appear more “natural”, even though it is not “humanlike”. This is yet another design strategy to make Alter appear as a sort of “human”, or humanlike

⁷⁴ In all fairness, Alter is the result of a collaboration between the Ikegami Lab and the Intelligent Robotics Laboratory, the Ishiguro Lab, at Osaka University. Alter's body, for example, is originally made as an android copy of a famous performer in Japanese storytelling, but later revamped as an experimental site to create “lifelike” movements.

⁷⁵ The geminoid server mediates between the robot and the system interface (computer), and thereby, to put it simply, maintains the link between the robot and its human operator. On the one side, insofar the robot is a dynamical system on its own by way of generating self-propelled “autonomous” movements, the human operator, on the other side, may then, via the operating system, perturb them by typing new commands. In effect, the geminoid server receives robot control commands and sound data from the remote controlling interface, adjusts and merge the inputs, and transmits and receives primitive controlling commands between the robot hardware.

form, while yet remaining highly generic and seemingly uncategorizable.

In front of Alter's pedestal foot, an adjacent sensory system of infrared (IR) and ambient sensors, encased in five transparent plastic casings, "feeds" Alter with visual, sonic, thermal and haptic information. Based on principles of artificial chemistry, the sensory system is itself internally organized to mutually share and transmit clusters of various forms of information – visual, sonic, thermal, haptic – which are then looped into Alter's internal systems. Alter's internal dynamical system is comprised of a central pattern generator (CPG) – a chaotic oscillator, which operates like an internal metronome, functioning much like Alter's "brain" - and a plastic artificial neural network (NN) based on the principles of biological neuronal networks. In other words, Alter's internal system is "layered" into three distinct components, which are each internally organized, while still also interacting with one another. If no "external stimulus is provided", Ikegami tells me, "if no information is supplied from the outside", Alter enters into an idle mode, into what the lab members call a "default mode". But once an external stimulus is provided, for example, if one steps close to Alter, contrary to if one waves at it at a distance, its internal systems respond to such actions accordingly, as Ikegami notes, "reading the external information based on accumulated memory". However, if one leaves the room entirely, which is to make external stimulus absent from Alter, it keeps its memory in order. This means that switching between the CPG and the NN, triggered by the information received by the sensory system, makes Alter create spontaneous behaviors, even though no stimulus is provided: the CPG is put to work when the sampling rate (the rate at which it takes information in from the environment) is low, and once the sampling rate increases, Alter learns through the NN.

Much of the inspiration for Alter's internal systems comes from somewhat recent scientific discoveries, for example, such as neurobiologist Benjamin Libet's (2004) discovery of "gaps" between nerve responses and conscious awareness, and neuroscientist Antonio Damásio's (2000) somatic marker hypothesis. Both theories propose a close connection between sensory stimulus and emotions, and the influence of this connection on conscious and unconscious decision-making, which means that physical stimulus *precede* conscious awareness and volition. In Libet's "time-on" theory, for example, he argues that sensory inputs must last at least 400 milliseconds

before converting unconscious correct temporal order to consciously experienced temporal order (Libet 2004). What these theories offer to Ikegami, I want to suggest here, is that they allow him to hypothesize that “life” or “lifelikeness”, provided that this is what is supposed to “emerge” on top of Alter, can be imagined as emerging from the very process of response to external stimuli on a fundamental neurological level. Yet, while these theories, according to Damásio and Libet, conventionally apply to real, organic living organisms, for example, used to describe how entities, such as human beings, operate on a neurological and pre-cognitive level, Ikegami here thinks of them to apply not only to organic things but also to non-organic, abiotic and artificial things, which includes applying them to Alter.

Now, by installing such theories into the design scheme of the internal systems themselves, and by making algorithmic specifications of them, this allows Alter to “experience” the world through its own, artificially-installed “perceptual filter” and through embodied engagements with its surrounding environment. More concretely, Alter is made able to interact with people once they are near it, and then store its “experiences” as “memory” when people are absent. When nobody is absent, it enters into its default mode, as Ikegami tells me, “in the same way as we do when we’re idle”. In this way, the autonomous sensor system is basically Alter’s perceptual organ⁷⁶, designed, as some of lab members put it, to “capture the dynamic ambience” of Alter’s immediate environment. In its default mode, Alter harbors its potential for learning, which is based in the number of external stimuli received, and by “sensing” the environment, the data is then transported to and processed through the dynamic interactions between the CPG and the NN, and then finally distributed to the actuators, in effect making Alter’s body generate “self-propelled” movements and “autonomous” behaviors. As Ikegami summarizes, “Alter produces action by translating the micro-neural firing into macro-body motion”, in this way fulfilling the basic idea in complex systems theory the low-level interactions that lead to the emergence of global, higher-order behaviors in the technical guise of a subsumption

⁷⁶ Note here that Alter’s eyes and ears, for example, are not made functional sensory organs but distributed to the sensor network itself. “Though Alter has eyes and ears”, Ikegami noted, “they are non-functional”. But Ikegami saw this as a stepping stone to further develop Alter’s sensory organs by “installing”, say, cameras in its eyes and make “richer” sensors to expedite “greater sensations”. To go back to chapter 3, this is a system, or an idea of a perceptual filter, also incorporated into Lana’s mutants.

architecture⁷⁷.

Finally, Alter's self-propelled movement is also accompanied by its voice, by "singing" in an analog drone-like voice. Technically, this happens by simultaneously scraping the sonic frequencies accordingly to its movements, so that Alter's "voice", the lab members tell me, "is generated in real time". Yet Alter's voice, Ikegami tells me, is not a "language", which is understandable to human ears because if it was, he asserts, it would defeat the purpose of it, "if we used a clearly understandable language, such as Japanese or English, Alter would simply become an imitation of a human being, and Alter's appearance would only detract from the overall experience". Hereby, to avoid "detracting" from the overall "experience", the lab members use a software synthesizer (u-he zebra 2.0) to modify and transduce the sound of a human voice into an analog, drone-like sound. Here, the point is that Alter is, again, supposed to be evaluated according to what it is, not with reference to what one might suspect it is purported to be an imitation of. Alter, in the other words, has no referent, no "model species" (cf. Suchman & Castañeda 2014).

In sum, Alter's appearance and performance, to the human sensorium at least, overwhelmingly appear to do many things: it signalizes, pantomimes, gesticulates, blinks, dances, speaks, sings, charms, appeals, and touches. But such actions, or such appearances, as it were, may only surface, I think, through the work of interpretation, which is one of the key points about Alter: that one needs to evaluate Alter, not in terms of its mimetic accuracy to biological life forms, but in terms of its outward "actions" and "behaviors" alone. Nor may it necessarily be assessed and evaluated according to the "backend" intentions, plans and motivations, which Ikegami and the lab members are working into its technical design, but for how it *affects* the beholder, despite its overt artificiality. Lastly, Alter may not even be known by its likeness to anything other than itself: there is no referent, no corresponding entity to which it is supposed to be analogized. In sometimes smooth, sometimes jerky, yet beguiling movements, Alter is smoothly in sync with the tunes of its own songs, and in a word, the affective "experience" of Alter's overall appearance and outward performance - the internal mechanisms and backend principles notwithstanding - nevertheless reveals that it is somehow "lifelike". But moreover, it is, despite the fact that it is

⁷⁷ Read: complex dynamic systems (cf. chapter 2) or MDF-system (chapter 4).

supposed to be neutral, still enmeshed by its creators in a narrative frame guiding us to understand Alter with reference to “life”. To this end, Alter is, above all, an aesthetic thing, both like and unlike organic life, yet it is explicitly narrated to be wholly artificial, and the lab members want to keep it that way.

The Power of Ambiguity

Appraisals of biology have discerned that living substances, for example such as organic compounds, but also pieces of software, may act as what rhetorician Richard Doyle (1997) calls, “rhetorical devices” (Doyle 1997; 2003). In his work *On Beyond Living*, for example, Doyle points out that artificial life researchers have a tendency to use their computer simulations as rhetorical devices, which allows them to enliven them with narratives reeled from the reservoirs of our culture (Doyle 1997). In this way, Doyle shows how computer simulations may serve as materially-instantiated theories of, say, biological change or open-ended evolution. Yet, there is nothing, Doyle claims, that necessarily forces us to view computers (i.e. their speed, capacity to set math in motion, informatic logic, etc.) as “real” instantiations of artificial life. Put differently, computers, and what they are capable of doing, function, according to Doyle, as “rhetorical software”: devices that allow artificial life researchers to say *more* than what their simulations can do in and of themselves. While this is also the case for many of the models at the Ikegami Lab, as we have already seen, this also includes Alter, though not described, nor imagined as a computer model as such, but equally used as a rhetorical device not to manifest a theory of biological change, but rather to manifest some sort of material “proof” of the existence of artificial life, as an alternative to biological life, as a sort of *possible* life. Alter is, in short, according to its associated discourse, supposed to be understood without reference to biology, yet still with reference to life, which is itself a productive tension aiding its immediate indeterminacy. What this, in turn, allows is the opening of up a new space of possibility, a new foundation for a fresh causal ontology⁷⁸.

⁷⁸ That is, in relation to what we explored in the previous chapter, chapter 5, on fields of possibility.

Moreover, in a somewhat similar fashion to Doyle, anthropologist Natasha Meyers (2008) also argues that “liveliness” is a narrative effect of researchers’ embodied work. For example, in modeling protein conformations, researchers may narrate stories about biology, she writes, that “keeps bodies in time” and “conjures a living world that escapes capture” (Meyers 2008:246-250). The narratives accompanying Alter are unmistakably performative in the sense that they sketch, and I argue, even disrupt, the narrative center and interpretive frames by which Alter is supposed to be made sense of (cf. Sengers 1998; Kember 2003). However, the narrative frame in which Alter is set nonetheless keeps centering on “life”, as an arbiter for understanding what it is, but it does so without alluding to life as a fixed and fully-determined category. Or, in other words, “life” is the reference point to which Alter is pushed to make sense, but not as a sort of biological life, but as something intentionally synthetic and artificial, yet still “lifelike”. To this end, I would like to maintain that this reference to “life”, whether someone is convinced that Alter is a true artificial life form or not, is only tenable *because* life is already to begin with a troubled and troubling category.

The narratives and design schemes tethered to Alter, I think, are thereby playful experiments on the tension between life organic and life artificial, and on the forms “lifelike” things might take without allowing the narrative center to take root in some prior (biological) existence. The narratives told by Ikegami and the lab members conjure alternatives to how one may imagine the living world, which are narratives that play on the ambiguities between the living and the nonliving, using words such as “life”, “mind”, or “autonomy” to describe things that are conventionally believed to be nonliving. Alter’s features are *not*, then, as the lab members also explicitly claim, supposed to be approximations to the biological, yet they still make heavy use of biological tropes to make sense of its “liveliness”, words and tropes which they identify with the animated and silicone-wrapped body of Alter itself. As Doyle, moreover, points out, simulations may be rhetorical devices, but the general rhetorics of artificial life, he claims, often conflate “lifelike” with “life itself”, proposing that the work of turning “models of life” into “examples of life” reveals an absence of a coherent reference for life, even as it grounds “life” in abstractable for formal properties (Doyle 1997:122). To this end, both Meyers and Doyle stress that liveliness

is nonetheless rhetorical and narrative: liveliness or lifelikeness are categories constructed from the stories people tell about life.

Now, Alter holds a strong position of ambiguity, and there is also something to the design choices of Alter, besides the way the lab members describe it, that reveals it to be purposefully sketchy. This deliberated sense of indeterminacy, inconclusiveness and incompleteness, I think, is exactly what makes *Alter* *persuasive*, or at least appealing, to our senses, while it simultaneously complicates *how* we should make sense it. As revealed in the introduction to this chapter and in the previous section pacing this one, Alter's face is almost liquid in the ever-changing expression of the featureless, white surface, while its androgynous face reveals neither age nor gender. When Alter performs, its face embodies the voluminous music in waves of emotive expressions: melancholy, joy, ecstasy and so on. In this sense, while Alter's face may seem generic, while it is not really so: it is blank, yet dramatic and emotive, sometimes even "humanlike".

While Alter's face displays a generic "humanness" of some sort, its exoskeletal body is exposed as intrinsically machinic and mechanical. The back of its "skull" is open, the internal mechanics and circuitries laid bare, which in turn reveals how the lively facial expressions are set in motion by moving gears and metallic joints. Alter's body, in other words, is a visible assemblage of synthetic parts, which are nonetheless animated in dynamic and fluid organic motion. What the design of Alter reveals, then, even overtly, is both his frontend and his backend simultaneously, which is a self-conscious point in itself in relation to how one should apprehend and understand it. Or, more precisely, these are active and deliberate design choices, I will claim, that have been made to render Alter purposefully ambiguous and ontologically indeterminate.

Finally, the close connection of Alter's body, face, and performance to artistic expressions⁷⁹, I want to suggest, is not an accident or incidental, but rather an intentional approach to its design. Alter, in this sense, is deliberately made to balance on scales human and nonhuman, artificial and biological, which in turn leaves open an

⁷⁹ This is, needless to say, a nod to Ikegami's sense of artistic expression as it pertains to the things they make at the lab.

equivocal space disclosed to interpretation, a space in which the audiences at *Scary Beauty*, for example, or the lab members themselves, or someone like me, may be allowed to *add* their own readings and interpretations of Alter itself, additions that are possible, I suggest, *because* of Alter's inherent ambiguity. In other words, this recalls Ikegami's notion of trying to conjure up a sort of shared "middle ground", as we saw in the previous chapter, which is integral to the lab's self-invented epistemology, a sort of intersection or interface at which machinic entities, such as Alter, and human spectators can meet and relate across their obvious differences. Alter is artificially very real, not some imitation of the real.

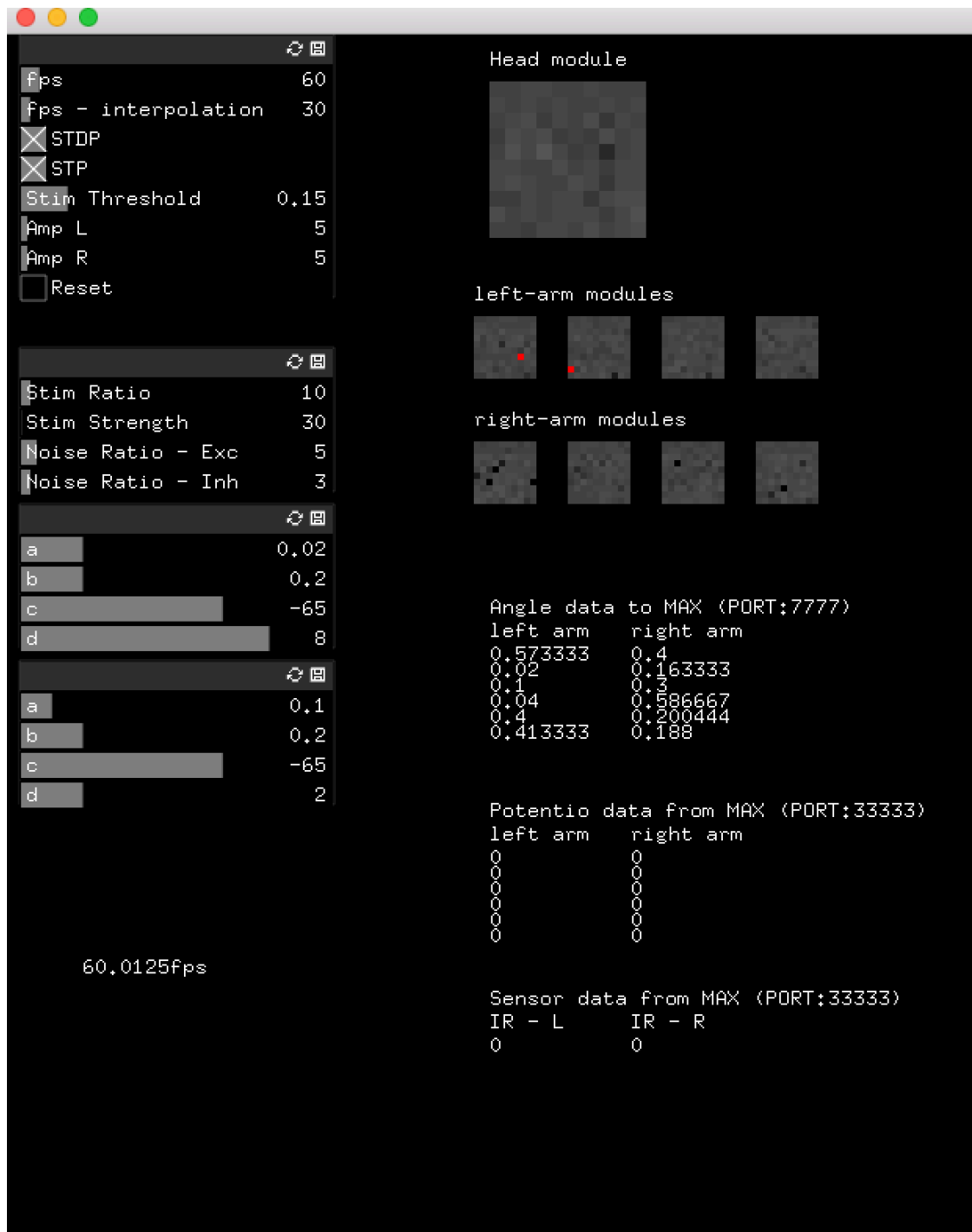
Collaborative Sensing Practices

While Alter is supposedly imagined, as "neutral", it is also, according to Ikegami, considered to be "pre-ontological" in the sense that it is not supposed to be semantically, semiotically, or even ontologically ordered from the beginning. Yet, although Alter is imagined to be "pre-ontological", I still want to maintain that it never really is, as already pointed out. Doi Itsuki - a trained biologist, computer scientist, musician and PhD fellow that lab - and Atsushi Masumori⁸⁰ - a trained computer scientist and master student at the lab - are primarily responsible for heading the Alter-project. Doi and Atsushi, while I was doing fieldwork, often worked from home or spent time doing experiments at the Miraikan, where Ikegami had borrowed a spacious hall for conducting research experiments.

During experiments, I experienced during fieldwork, Doi and Atsushi had plenty of hermeneutic tools at their disposal when it came to how to discerning "massive data flows". That is, unlike the audience present at show *Scary Beauty*, Doi and Atsushi, when making preparations for *Scary Beauty*, or when doing experiments with Alter in

⁸⁰ The lab members, Doi and Atsushi, are both Japanese students at the Ikegami Lab. During fieldwork, I rarely saw them on campus, except when they attended lab meetings or other group meetings. They were not usually on campus, often working from home, if not doing experiments at the Miraikan. I tried several times to get an appointment for doing an interview with both Doi and Atsushi, but never managed to do so. They never really officially declined doing an interview with me, but I quickly got the feeling that they felt uncomfortable about it, so admittedly, I respectfully accepted their reluctance to do so. However, on the contrary, I managed to join them during experiments, where they kindly guided me through their work to the best of their ability.

general, parse what they see in a mathematical idiom, that is, in terms of “intervals”, “patterns”, “directions”, “motion”, and “frequencies”. This means that they are already thoroughly sieving their readings of Alter’s operations through a highly technical grammar that has some of its most canonical expressions in the form of written equations. More concretely, when Doi and Atsushi were fluttering around on the seventh floor of the Miraikan, conducting experiments on Alter, which basically involved tweaking numerical values on computer screens to the loud noise of the two large air compressors, their computers were looped into Alter’s “operating system”. In turn, what became visible on their computer screens was, metaphorically speaking, Alter’s “experience”, which was translated into numerical values, red dots and blips on lattice-like grids. Moreover, what became visible to them was “massive data flows”, and so, they would occasionally instruct one another to move to different locations in front of Alter’s sensors, blocking the sensor units with their feet, and positioning themselves relative to Alter’s body, themselves becoming part of the “flow”. And when doing so, they sought to anticipate its reactions to adjust their programming accordingly – a “dance of agencies” (Pickering 2010).



Now, the “liveliness” Doi and Atsushi are looking for in their experiments with Alter, in contrast, I think it is fair to say, to that sort of liveliness audiences might be looking to detect at *Scary Beauty*, is one that turns mathematical, as oscillating curves and blips on their laptop screens, not some mysterious or “lifelike” presence “emerging” through affective responses as such. Their readings, then, are instead keyed to arrive at a rhythmically and dynamically, even mathematically attuned digital discernment of Alter’s operations, not to tease out some new meaning of life as such. This

suggests, I think, that Doi's and Atsushi's readings of Alter's operations, unlike the audiences at *Scary Beauty*, are already filtered through a grid of interpretation, yet a grid of interpretation, I still think it is fair to say, which is *different* from the one available to the audiences at *Scary Beauty*. Insofar Doi and Atsushi, when doing experiments, following Gabrys and Pritchard (2018), are emplaced in collaborative sensing practices, they are, in a sense, reading Alter "reading" its own "environment" of "massive data flows"⁸¹. But, they do so in a way that churns "experience" into a mathematical idiom, which is in turn filtered into a system of signs legible to them. In other words, what I want to point out here is that Alter figures for Doi and Atsushi to extract information from the real world, or better, to extract massive data flows from the environment, whose qualities must be taken into account only to be factored out into mathematical syntax. For Alter to be a medium with which to relay information from the real world, it needs to be abstracted *out* from its ambient surround, and translated into mathematical syntax in order to make sense for the lab members.

To Doi and Atsushi, the human-machine interface, although one confined to the experimental space at Miraikan, understood here as a specific, localized form of collaborative sensing practices (cf. Gabrys & Pritchard 2018), is organized not by making affective and bodily responses to Alter's movements and sounds, but rather by translating and ordering Alter's "experience", obtained through its sensor system, into a mathematical syntax and a semantics of correspondence. This is, of course, recognizable, in part, through the silicone skin and motors of which Alter is made, and through the collaborative sensing practices, in which it is emplaced. Put differently, the humanly-shaped and porcelain-faced android is a sort of "black box" that may be opened up to read as a material and semiotic delegate for what the artificial life researchers associate with vitality, which is primarily data and information. But it is not as such "pre-ontological", since its operations, at least, are already filtered and made sense of according to a mathematical idiom, an idiom by which it is made sense of.

⁸¹ I believe there are further investigations to be made here on questions about who is reading who in times when the world is becoming increasingly "sensorial", that is, though technologically-mediated and remote sensing practices.

Now, on the contrary, though, I want to suggest that if one turns to the audiences at *Scary Beauty*, it is fair to say that they may *not* sense and/or read Alter's performances according to mathematical syntax, but rather as if it has some sort of *kokoro* – or presence, which entails a range of meanings: the soul, the spirit, the mind or consciousness (cf. Sone 2018). The *Scary Beauty* performance, described in the beginning of this chapter, to which I now turn, offers yet another set of collaborative sensing practices, which involve not so much the work of translating Alter's experience of the world into mathematical syntax, but rather constitutes a new indeterminate space open to other interpretational regimes. Allow me to return to the stage.

Scary Beauty

In the show *Scary Beauty*, Alter appears to embody a sort of supra-human power, or some sort of presence, like some purified, heightened version of the human itself: on the one hand, very concretely “humanlike”, and on the other, a kind of abstract ideal, not entirely unlike the Platonic idea of the ideal forms. Alluding to the human form, while still holding in abeyance that it is, in fact, nonhuman, renders viable the possibility that Alter can potentially *actualize* many different modalities and presences, some of which may be interpreted as scary, ugly, beautiful and anything in between or none at all. That is, Alter's allusion to ideal forms, activates the imagination of audience to allow for further interpretations of what it could become. If *Scary Beauty* is a specific form of collaborative sensing practice across putative differences of human and machinic entities, in which Alter, as a technology, obtains an ideal form for imaginative effects, it shares similarities to what anthropologists Morten Axel Pedersen, David Sneath and Martin Holbraad (2009) refer to as “technologies of the imagination” (Pedersen et.al. 2009). To them, technologies are means to produce indeterminate imaginative effects, which may be taken to mean that technologies, understood concretely in the most colloquial of senses, to be inherently processual and culturally-specific skills or techniques that people use towards certain outcomes in their handling of everyday life (Pedersen et.al. 2009:21). The imagination, on this part, is taken to be an *outcome* of a specific technology, either as

artefact or as process or both, whose basic characteristics is that it is intrinsically underdetermined. In short, technologies of the imagination bespeak a space of potentiality, or a field of possibility, which is open to new interpretive regimes.

Taking this notion of the imagination, then, it is the often-unsuspected outcome of determinate processes and tools, as technologies of the imagination “open imagination up”, yet often in uncontrollable and indeterminate ways (cf. Pedersen et.al. 2009). Put differently, Alter may amount to be a hardline determined attempt to produce indeterminate effects. Furthermore, if one follows this notion a bit longer, Alter may also be viewed in the double meaning of a technology, both as a process *and* a technological artefact, created, indeed designed, to produce imaginative outcomes. Its design itself, as Ikegami implies, intentionally creates, I once again want to assert, an indeterminate space for the imagination, a space open to new interpretive regimes. Alter, insofar we accept it is emplaced in collaborative sensing practices, I argue, thus renders a space of indeterminacy needed for audiences to connect with it, becoming itself a site in which the imagination and various interpretations of the audience can take hold. Because Alter’s face, as a human form, for example, may not yet be “filled up” by the presence of a complete human person, or imbued with some other living quality, it can be actively imbued with meaning and power. Likewise, while Alter’s voice, as it sings to the audience, may seem familiar, it is also strangely unfamiliar and unhuman, allowing, in turn, for suspending disbelief in the fact that it is animated by algorithmic scripts and air compressors.

While Alter’s face-body distinction in its design reveal a dichotomy between human and machine, the body in itself conveys its own organic fluidity. But while the lab members claim that Alter is “autonomous”, it is, however, not the author of its own movements, but rather animated by the algorithmic scripts made by Doi and Atsushi, as we saw in the previous section. Moreover, the algorithmic scripts putting Alter to life, into motion, are also supported by the set of air compressors, literally, one may pun, *breathing* life into Alter. Despite its clear mechanical design, Alter is thus rendered “lifelike”, which is neither suggesting that it is fully alive nor alive in any biological sense. As such, since Alter is, in a sense, placed in an interpretive frame coalescing on the notion of “life”, it simultaneously draws attention to itself as an

instantiation of a sort of artificial life, which the audiences know is oxymoronic. Still, however, it is somehow spirited or endowed with a certain form of presence or lifelikeness, what Ikegami also sometimes refer to as “kokoro”, which cannot immediately be identified or ordered into a fixed frame of reference.

Furthermore, by explicitly and deliberately displaying Alter’s body to be pure mechanics, the design also reveals that human forces have been invested in it: the very mechanical functionality itself exposes the design intentions, ingeniousness, inspirations and ideas put into constructing Alter, which vividly testifies to the ambition of the Ikegami Lab to “construct” artificial life in the real world with an emphasis on the fact that the things they make are indeed constructed by human hands. And so, too, it is exactly by virtue of Alter’s ambiguity, I argue, that its affective qualities may surface as it pertains to the so-called “new epistemology of artificial life”, as outlined in the previous chapter. In other words, by actively playing on the tension between the artificial and the real, the living and the nonliving, the human and the nonhuman, I argue, Alter becomes productively *incomplete* in the sense that it evades any fixed set of significance. And this works, once again, exactly because life is already to begin with a troubled and troubling category.

Allow me to elaborate. In the show *Scary Beauty*, Alter’s presence and performance are explicitly and intentionally removed from the realm of realism, as Alter, according to Ikegami, is not meant to be read by the audience as realistic. Though still, it may be read as an instance of artificial life, but not necessarily as realistic. Thus, *Scary Beauty* works as a new exploratory human-machine interface, or, as I propose, a new specific form of collaborative human-machine sensing practice, where Alter is deliberately one step removed from any realistic depiction not only of the human, but also from any known biological organism we may conventionally associate with life or the living. However, on the contrary, to the audience, Alter is vividly displaying movements that may easily translate to organic forms, which creates a productive tension between the living and the nonliving, the real and the unreal. But it also, then, makes the unreal sufficiently real enough to be believable.

In other words, *Scary Beauty* works because the sum of Alter's parts does *not add up*, to use philosopher Brian Massumi's (2002) words, in the sense that it is "suspended" between structured parts and meaningful outcomes (Massumi 2002). But the audience at *Scary Beauty*, is also suspended by their immediate inability to determine what Alter really *is*, yet they are still somehow moved by its presence and by its performance. Alter, in this way, I want to suggest, interfaces a slew of different indexical regimes without resolving into any of them. Or, more precisely, borrowing once again from Massumi, Alter becomes a sort of guarantor that "life" cannot immediately be incorporated into a fixed set of significance, with Alter itself "not semantically or semiotically ordered", yet still linking, or at least lingering in a productive tension between, what is normally "indexed as separate" (Massumi 2002:24): the real and unreal, the artificial and the biological, the human and the nonhuman.

To this end, one may add that this tension is in alignment to other design strategies, for example, as anthropologist Jennifer Robertson (2010) notes in her study of Japanese social robotics, that Japanese roboticists explicitly strive for what she terms an, "active incompleteness", which is tied to the notion of "ba" – a concept that encompasses a non-dualistic concrete logic meant to overcome the inadequacy of the subject-object distinction (cf. Robertson 2010:14). Robertson defines "active incompleteness" as a "dynamic tension of opposites that [...] never resolves in a synthesis" (Robertson 2010:14), which is exactly what I think Alter also embodies. However, while Ikegami does not identify as a roboticist⁸², but as an artificial life researcher, Robertson's notion is useful here to make sense of how Alter occupies a dynamic tension between seemingly separate domains, which becomes constitutive of a space for new emergent relationships between artificial life systems and human audiences that rest on contingency and co-creation, i.e. on interactivity (cf. Penny 1996).

Scary Beauty, to conclude, becomes not only a specific form of collaborative human-machine sensing practices, but an especially evocative one, rewiring Gabrys and Pritchard, in which the audience encounters the unfamiliar, unknown, and

⁸² In fact, Ikegami was annoyed by people who mistook him for being a roboticist rather than an artificial life researcher and complex systems scientist.

unexpected, or the “contingent”, if one follows Robertson’s terminology (cf. Robertson 2010). This sort of human-machine interface is, I want to propose, a potent site for creating new meanings of life, to grow and foster new understandings of what life could be (cf. Langton 1989). It is a performative site, in other words, in which artificial life systems can be imbued with some sort of social, cultural and lifelike presence. In the event of *Scary Beauty*, and the assemblage of artistic and scientific genres that convene here, the suspension of Alter, between the pre-defined, the indeterminate, and the non-defined, produces a certain kind of reception for the audience, which is different, I suggest, from the one produced for Doi and Atsushi when conducting experiments, something more impressionistic. In both cases, though, Alter interfaces different connections between artistic, technological and scientific domains and practices. Now, in the final section, I want to wrap up how this equals what I call a parallax view of life.

Parallax Machines

In conclusion, I want to suggest - particularly on the basis of *Scary Beauty* and to a lesser extent on the basis of the experiments on Alter conducted by Doi and Atsushi - that Alter comes to function as what I call a *parallax machine*, an abstract and material entity that materializes the culturally specific ontologies, epistemologies, theories and concepts, which are fostered at the Ikegami Lab. As a parallax machine, Alter embodies the social, cultural, and scientific worlds of the Ikegami Lab and artificial life, and it does so for aesthetic ends. If Alter is a parallax machine, it is so because it is an epistemic thing that serves to destabilize any biologically-established understandings of life (cf. Rheinberger 1997), especially those clinging to a determinate and inviolable definition. Second, because Alter is a machinic object with which the lab members may build new viable instantiations of human-machine interfaces in the sense of creating new modes of relatedness, apprehension and inference, which are spun across a range of categories normally indexed as separate. And third, because it becomes a social tool for building alternative narratives of life, narratives that center on “life” being first and foremost an “emergent phenomenon”, but which actively rework a perspective of life according to what I call a parallax

view of life – a view that renders life true identity not into a matter of either-or, but into a matter of both-and.

More concretely, Alter is a parallax machine, which materializes the cultural artifacts of the Ikegami Lab itself *and* invites audiences, lab members alike, to adopt a parallax view of life. A parallax view of life, I claim, is made possible exactly *because* Alter is deliberately constructed to occupy a tension between the determinate and the indeterminate, the complete and incomplete, simultaneously putting together seemingly incompatible notions of life in the same instance. Alter, in other words, both materializes and stimulates a parallax view of life in the sense that it instantiates what philosopher Immanuel Kant called “transcendental illusion” (cf. Karatani 2003) by itself becoming a material expression for phenomena, which are mutually untranslatable to one another, which is why it can only be apprehended in a kind of parallax view. As such, I argue that Alter is at once a materialization of, and an invitation to, a shifting perspective on life without resolving into synthesis or any fixed set of significance by virtue of occupying a space where there is no rapport between the artificial and biological. Yet, still, in this space, these categories are closely connected, through a collaborative sensing practices, where they may sometimes be identical, sometimes not, as if they are on the opposed sides of a Moebius strip.

This parallax view is brought forth in the productive tension between a range of things. For example, if Libet’s “time-on” theory is a valid disposition and capability inherent to biological organisms, and such dispositions and capabilities are replicable, indeed “realizable”, in artificial media, such as Alter, what then is the difference between the artificial and the biological? If biological dispositions can be rendered technical and artificial, then by what criteria may we differentiate the natural and the artificial? More broadly, if the physiochemical features of “real” living things can be technically reproduced in artificial media, in non-organic bodies, and if the perceptual features, which characterize living beings, can be accurately installed in artificial systems, by what metric may we determine what the living really is? And, in relation to *Scary Beauty* in particular, if Alter, by virtue of its ambiguity, suspends the audience in a tension between indexical regimes, making them, in turn, immediately

unable to determine what it really *is*, yet while still being moved by its presence and by its performance, who is really to determine what life is and what it could become? In other words, the construction of parallax machines, I argue, is the construction of limit forms of life, or limit cases of life (cf. Helmreich 2016; Roosth 2017), such that conjectures about what constitutes life and the living destabilize any solid notion of “life”: i.e. if things nonliving are living, and vice versa, or things real are unreal, and vice versa, Alter becomes a parallax machine that offers a parallax view of life.

As it happens, parallax machines, in the case of Alter, celebrate a metaphysical quality, namely “life itself” (cf. Foucault 1971), however, if life itself is a metaphysical concept, it is in turn haunted by an anxiety about the stability of its identity in a regime of reproducibility. In other words, if Ikegami and his team of researchers are able to construct or create potent “signs” or “signatures” of life, they become reproducible signs of some irreproducible authenticity, namely “life itself”, which then destabilizes the very conceit of irreproducible authenticity. “life itself”, then, can only here be grasped, I want to claim, in a kind of parallax view, one that must absorb all the inherent ambiguities integral to the conceptual trouble bedeviling “life itself”. And if this is the case, life is by definition definitionally unstable, known more by its associated disequilibria than by its equilibria (cf. Helmreich 2016; Thacker 2009). Or rather, life is graspable only by a kind of parallax view. Moreover, if one follows this logic to its logical conclusion, what one may argue is that parallax machines can also be both: *indices* of life and *life itself*, and they work exactly because they vex the boundaries between the natural and the artificial, the real and the simulated, the real and the unreal, and so on, holding the potential that any “epistemological” shifts in the subject’s point has the corollary of an “ontological” shift in the object itself. In other words, parallax machines are machinic entities, I stress, that allow for a parallax view of life, one that does not reduce “life” to a question of either-or, but rather expands it to a question of both-and.

To gloss this in one a well-worn paradox at the heart of quantum physics, famously espoused by Albert Einstein’s wave-particle duality, artificial life, through the construction of parallax machines, I want to contend here, is also a cultural formation of modern theory based on a mode of parallax, an enterprise that fluctuates in an

epistemological vertigo between realms organic and inorganic, natural and artificial, living and nonliving, real and simulated, which is exactly what parallax machines are meant to capture⁸³. But what I also want to capture by parallax machines is how much Alter offers material expression to Ikegami's ontoepistemological framework that I have called Ikegamianism precisely because Alter's design and the entire setup of *Scary Beauty*, as a collaborative sensing practice, is rooted in Ikegami's own understanding of reality and his own self-articulated epistemology, by which we are encouraged to sound out new meanings of life more impressionistically.

Thus, in conclusion, parallax machines materialize both Ikegamianism and a parallax view of life, with life becoming an emergent, something always-already imperiled or nearly there, yet still an indeterminate phenomenon, situated in between many different indexical registers, between the real and the unreal, the biological and the artificial, the artistic and the scientific, the mechanical and the organic, the human and the nonhuman. And this is precisely, I argue, *how parallax machines become powerful tools to Ikegami's project to establish his own paradigm and in terms of making powerful claims to "life"*. Now, in the final chapter, I offer a summary of this thesis and some concluding remarks.

⁸³ I want to add here, pushing this argument a bit further, that artificial life's appeal and persuasiveness, insofar one believes in the promises and claims made by artificial life researchers, is conditioned on its practitioners' ability to balance and navigate in such a vertigo for ends productive and beneficial to its own cause.

7

CODA



A parallax machine diffracting a parallax at the National Museum of Emerging Science and Innovation, Tokyo, Japan. Photo courtesy of: author.



Doi Itsuki and Takashi Ikegami inspecting Alter during an experiment at the National Museum of Emerging Science and Innovation, Tokyo, Japan. Photo courtesy of: author.

Coda

Both during fieldwork, and during the months I finished writing this thesis, stories about artificial life's achievements clogged the news headlines: *Japan Has Birthed a New Life Form: The Drunk Android* (Bloomberg Businessweek), an article written by an equally drunk journalist, who interviews Ikegami about Alter. To go back to my introduction, in which I uttered concerns for what “species” might mean in our contemporary moment of the new sciences of the artificial, the author of the Bloomberg-article seeks to settle the score, “Japanese researcher Takashi Ikegami” he writes, “has built an AI-infused android he sees as the start of a new species” (Bloomberg Businessweek 2016). This irreversibly problematizes any stable definition of species purity, one might say, destabilizing “species” as a coherent category altogether. What the author is hinting at in his amazement of Alter is that artificial life may rupture the notion of species, both materially and discursively, potentially rendering the notion of species either more capacious or utterly meaningless. Species, this implies, however, may also be materially and synthetically constructed, or to use the terminology of the author the article, “AI-infused” androids may also be “birthed” as a “new species”. However, as illustrated in this thesis, the artificial life researchers at the Ikegami Lab do indeed talk about species, but they do not describe the artificial systems as a new species. Rather, their claims here are more sedated and less exaggerated. Yet, they subtly suggest, though, that artificial systems, such as Alter, have the *potential* for becoming a new species, indeed constituting what John Johnston (2008) calls a new “machinic phylum” (Johnston 2008).

In another article, posted on the online magazine Medium.com, *Beyond AI: It's Time to Think About Artificial Life (Again)* (Medium), another author ruminates that artificial life technologies are not made purely for the “efficiency of humans, but rather it is something that will induce new ways of understanding for humans and will make it possible for humans to gain new perspectives of the world.” (Miyamoto 2018). Refraining from using “species” to describe the subject matter, the author here seems to be more in tune to Ikegami's own ideas, echoing his idea that artificial life technologies might, or even should, offer new perspectives on life. Without mention, though, this article is also implicitly in line with my argument in thesis: that parallax

machines both materialize ways of seeing and attending reality and to knowledge *and* offer new ways to see and attend to reality. Or, in my own words, parallax machines materialize Ikegamianism and offer a parallax view of life. However, I have shown in this thesis, such ways of crafting, articulating and attuning to the world are not given, emerging in a vacuum, but are rather thoroughly and carefully threaded through social practices and the skillful technical construction of new technologies and imaginaries.

In yet another, somewhat similar online article, *Life, Love, and Robots: A Conversation* (Felixonline), the author, after interviewing Ikegami, takes artificial life to the future. After her interview with Ikegami, she is left pondering about artificial intelligence and the definition of life, wondering whether the future will really contain some sort of “Ex Machina-style androids for us to fall in love with?”, whether she will someday in the future find a version of Alter, she further ruminates, “on the couch, eating Ben & Jerry’s and watching Love Island?” (Hertzberg 2019). But what is conspicuously peculiar about this article, I think, is that the author explicitly compares Ikegami to Victor Frankenstein and describe him as a “misunderstood genius” (Hertzberg 2019). This curiously echoes yet another argument in this thesis: that Ikegami assumes as sort of Jungian archetype, the artist-scientist, and becomes the embodiment of what Weber calls charismatic authority. As a leader of the Ikegami Lab, Ikegami is described by the lab members as a creative “genius” and a “pioneer”, who creates “sacred norms” to be followed. Indeed, Ikegami commands his laboratory by his word, his emotional posture and personal qualities, and he does so in ways that make him the center of his own cult of personality.

While such headlines, although in dramatic ways, somehow capture, I think, what is at stake in our contemporary cultural moment when artificial life researchers seek to construct new artificial systems to better understand what kind of a thing life is, they reveal how Ikegami has largely succeeded in attracting attention to himself and the field of artificial life. On the one side, these articles reveal that artificially-created things, such as Alter, do indeed convince people that they may be “real” instantiations of life, or even be a new “species” in their own right. Moreover, “life” may equally, then, be constructed and understood through assembling bits and pieces of synthetic materials and code. On the other side, though, these articles also reveal that

artificially-created things somehow impose upon us, or are supposed to impose upon us, “new ways of understanding” the world and force us to take “new perspectives” on things. Finally, we might even, as one of the authors of the articles implies, “fall in love” with artificial life technologies, such as “Ex Machina-style androids” and watch hokey reality shows on the couch eating ice cream. To this end, one may go back to the idea of “technologies of the imagination” (Pedersen et.al. 2009) to suggest that the construction of new artificial systems are very determinate ways to produce indeterminate effects, the effects here being that news headlines are clogging to dramatize the construction of the artificial, heralding the promise of artificial life to deliver not only new life forms but also new forms of life (cf. Helmreich 2009).

Yet, the proliferation of such “dramatizations”, evidenced in the articles, too, I think, only bolster Ikegami’s own position and enforces belief in artificial life, not only as a legitimate field of research, but also as a potential candidate for changing the world. As we have seen in this thesis, Ikegami is himself a dramatic type of person, whose charismatic authority might be said to be a primary driver of scientific and paradigmatic change. Indeed, Ikegami’s emotional posture and personal qualities reveal that changes in science may equally be attributed to new forms of charismatic leadership that define new social structures and relationships to impel scientific practice and change.

However, these headlines also surface less than a decade after the Fukushima Daiichi Nuclear Disaster, a Level 7 nuclear accident initiated by the Tohoku earthquake and ensuing tsunami in 2011, that discharged radioactive fallout to surrounding natural habitats, in effect, discharging, according to the Nuclear & Industrial Safety Agency of Japan (NISA), roughly 770 PBq (iodine-131 equivalent) of radioactivity, about 15% of the Chernobyl release of 5200 PBq iodine-131 equivalent. Summarizing the Fukushima Daiichi Nuclear Disaster like this, of course, is to self-consciously highlight another point in this thesis. Understanding the Fukushima Daiichi Nuclear Disaster in terms of statistics and numbers, to keep with Ikegami’s terminology, is the work “normal science”. Statistics, numbers, equations and formula, as Ikegami holds, are “layers of description” advanced by the paradigm he calls “normal science”. Thus, while the Fukushima Daiichi Nuclear Disaster might have nothing in common with

artificial life, it is nonetheless the dark side of “life”. And so, I self-consciously evoke this description of the Fukushima Daiichi Nuclear Disaster because it highlights, not how life is constructed but how it is destroyed. But also, as it has hopefully become apparent throughout this thesis, to highlight that any given material-semiotic, complex phenomena cannot simply be understood by the logic of normal science. Normal science, therefore, as Ikegami asserts in this thesis, is what must be deconstructed, and eventually relegated, to make way for what he calls a new epistemology of artificial life. And so, practitioners of normal science would, according to Ikegami, make sense of the Fukushima Daiichi Nuclear Disaster exactly by turning into numbers and statistics, not by seeking to understand the qualitative, social, cultural, ethical, moral and existential dimensions of such a disaster, things that must be taken into account when trying to make sense of our world. How “massive data flows” merge and dissolve, cut across and divert, is the very substance of reality and it is to this reality the artificial life researchers at the Ikegami Lab are committed. Thus, if this thesis is a postcard from a particular cultural moment in history, which I believe it is, where “life” has once again turned into an enigma, it describes and analyses a cultural moment where contemporary artificial life researchers are nowadays *constructing* new artificial systems as a means to *understand* what life is.

Life constructed, life destroyed, what ultimately matters to Ikegami and his team of researchers is how to make sense of life, how to create new meanings of it, by persistently asking by what mode of reasoning, by what metric, by what means, by what logics, should we really understand it. And so, my claim is that the construction of parallax machines, to reiterate, do a lot of work for Ikegami and the lab members: they are epistemic things that serve to destabilize biologically-established understandings of life; machinic objects for building new viable instantiations of human-machine interfaces in the sense of creating new modes of human-machine relatedness, relations that can be made only by constructing new artificial systems in the real world; and social tools for building alternative narratives of life, narratives that offer what I call a parallax view of life. Thus, the construction of parallax machines, I argue in this thesis, is at once the construction of material artifacts *and* a construction of a cultural formation. In this dual capacity, parallax machines embody what I have called Ikegamianism and offer a what I have called a parallax view of

life, a view in modern theory, which is based on a mode of parallax, centrifuging “life” in a sort of vertigo between realms organic and inorganic, natural and artificial, living and nonliving, real and simulated.

All this happens during a moment when the humanities and the social sciences have increasingly turned toward the material world in hopes of making sense of the domains of the “nonhuman” (cf. Barad 2008; Grusin 2015). The lab members, however, are turning their attention to artificiality in hopes of making sense of the living. And with the arrival of a slew of “new materialisms” (cf. Coole & Frost 2010) and “vibrant matter” (Bennett 2010), artificial life, then, may be considered a site with a strong nonhuman presence, a zone of corporeal and tactile synthetic bodies, of “three-dimensional and turbulent materiality” (Steinberg & Peters 2015:247). New materialisms of various sorts now seek to account for precarious and “vibrant” natures, and the convoluted relationships between biotic and abiotic, living and nonliving existences, being and agencies. But they sometimes do so by attending to a sort of pre-discursive, or in Ikegami’s terminology “pre-ontological”, material world, which is often posed as something outside human signification. Parallax machines, however, may be nonhuman, but they are, I want to claim, nevertheless the products of human action, ingenuity and dexterity, the result of social forces, serving, in turn, a very human desire to be affected, to learn, know, to understand and to generate new knowledge about the world and our place in it.

So, while I admire the conceptual creativity of new materialisms, fresh modes of thinking and speaking of nonhuman liveliness and agency, I read from my experiences at the Ikegami Lab that artificial life, following anthropologist Elizabeth Povinelli (2016), that Ikegami and the lab members creatively and innovatively extend to materiality, i.e. to parallax machines, the, “modes, qualities, forms and relations that already exist” (Povinelli 2016:440). That is, even though the artificial life researchers at the Ikegami Lab appeal and allude to the yet-to-be-known, to new horizons of possible worlds beyond the human, to how technologies might “escape us”, to highly material, artificial and nonhuman worlds, which they claim might be somehow outside human signification, they are still, I argue, very *human*, caught in the ripples of *culture*. As Ikegami charmingly reassures us, “basically, you can say

what you want to say. Science is really a matter of community, and it is the community who decides what counts as science and what does not.”

Literature

Aicardi, Christine. 2010. *Harnessing Non-Modernity: A Case Study of Artificial Life*. PhD Dissertation.

Alexander, Amir. 2014. *Infinitesimal: How a dangerous mathematical theory shaped the modern world*. New York: Scientific American/Farrar, Straus, and Giroux.

Bachelard, Gaston. 1998. *Le rationalisme appliqué*. Paris: Presses Universitaires de France.

Barabási, Albert-László. 2010. *Bursts: The Hidden Pattern Behind Everything We Do*. New York: Plume.

Barad, Karen. 2007. *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Durham and London: Duke University Press.

Bateson, Gregory. 1987. *Steps to An Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology*. Northvale, New Jersey and London: Jason Aronson Inc.

Beer, Gillian. 2000. *Darwin's Plots: Evolutionary Narrative in Darwin, George Eliot and Nineteenth-Century Fiction*. Cambridge: Cambridge University Press.

Bennett, Jane. 2010. *Vibrant Matter: A Political Ecology of Things*. Durham: Duke University Press.

Bergson, Henri. 1911. *Creative Evolution*. New York: H. Holt and Co.

Bijker, Wiebe E., Thomas P. Hughes, and Trevor Pinch. 1989. *The Social Construction of Technological Systems*. Cambridge: MIT Press.

Blaser, Mario. 2009. "The threat of the Yrmo: the political ontology of a sustainable hunting program." *Am. Anthropology* 111:10–20.

Bourdieu, Pierre. 1977. *Outline of a Theory of Practice*. Cambridge: Cambridge

University Press.

Bowden, Gary. 1985. "The Social Construction of Validity in Estimates of US Crude Oil Reserves." *Social Studies of Science* 15, no. 2 (May): 207-240.

Candea, Matei. 2007. "Arbitrary Locations: in Defense of the bounded field-site." *Journal of the Royal Anthropological Institute* 13, no. 1: 167-184.

Chadarevian, Soraya de, and Nick Hopwood. 2004. *Models: The Third Dimension of Science*. Stanford: Stanford University Press.

Chua, Liana and Amiria Salmond. 2012. "Artefacts in Anthropology". in *The Sage Handbook of Social Anthropology*, 101-114. London and Los Angeles: Sage.

Coole, Diana, and Samantha Frost, eds. 2010. *New Materialisms: Ontology, Agency, and Politics*. Durham, NC: Duke University Press.

Cronan, Todd. 2013. *Against Affective Formalism: Matisse, Bergson, Modernism*. Minneapolis: University of Minnesota Press.

Crutchfield, James P, and Karl Young. 1989. "Inferring Statistical Complexity". *Physical Review Letters* 63.2: 105–108.

Damasio, Antonio. 2000. *The Feeling of What Happens. Body, Emotion and the Making of Consciousness*. New York: Harvester.

De La Cadena, Marisol. 2010. "Indigenous Cosmopolitics in the Andes: Conceptual Reflections beyond "Politics"." *Cultural Anthropology* 25 (2): 334–370.

Deacon, Terrence W. 1997. *The Symbolic Species: The Co-evolution of Language and the Brain*. New York: Norton.

Delaplace, Grégory. 2014. "What the invisible looks like: Ghosts, perceptual faith, and Mongolian regimes of communication." in *The social life of spirits*, 52–69. Chicago: University of Chicago Press.

- DeLillo, Don. 2009. *White Noise*. New York: Penguin Books.
- Douglas, Mary. 2001. *Purity and Danger: an analysis of the concepts of pollution and taboo*. London and New York: Routledge Classics.
- Doyle, Richard. 1997. *On Beyond Living: Rhetorical Transformations of the Life Sciences*. Stanford: Stanford University Press.
- Doyle, Richard. 1997. *Wetwares: Experiments in Postvital Living*. Minneapolis: University of Minnesota Press.
- Emmeche, Claus. 1994. *The Garden in the Machine: The Emerging Science of Artificial Life*. Princeton: Princeton University Press.
- Enwezor, O. 2012. *Intense proximity: Guide de l'exposition, Palais de Tokyo*. Paris: Art Lys.
- Feferman, Linda. Simple Rules . . . Complex Behavior. Santa Fe, NM, 1992. Video.
- Feyerabend, Paul. 1975. *Against Method*. London: Verso.
- Fischer, Michael M.J. 2007. "Culture and cultural analysis as experimental systems." *Cultural Anthropology* 22 (1):1–65.
- Focillon, Focillon. 1989. *La vie des forms (The Life of Forms in Art)*. Cambridge: MIT Press.
- Foucault, Michel. 1971. *The Order of Things: An Archeology of the Human Sciences*. New York: Pantheon Books.
- Franceschini Amy. 2017. "Seed journey: retracing the path of disappeared seeds." *Makery: Media for Labs* (June).
- Furusawa, Chikara, and Kunihiro Kaneko. 1998. "Emergence of multicellular organisms with dynamic differentiation and spatial pattern." *Artificial Life* 4(1): 79–93.
- Gabrys, Jennifer, and Helen Pritchard. 2018. "Sensing Practices." in *Posthuman Glossary*, 394-95. London: Bloomsbury.

Galison, Peter and David J. Stump. 1996. *The Disunity of Science: Boundaries, Contexts, and Power*. Stanford: Stanford University Press.

Gammeltoft, Tine. 2003. "Intimiteten: Forholdet til den Anden". In *Ind i Verden: En Grundbog i Antropologisk Metode* 273–295. København: Hans Reitzel Forlag.

Geertz, Clifford. 1973. *The Interpretation of Cultures: Selected Essays*. New York: Basic Books Inc.

Gellner, Ernest. 2003. "Concepts and society." In *Ernest Gellner: selected philosophical themes*, 18-46. New York: Routledge.

Geraci, Robert. M. 2010. *Apocalyptic AI Visions of Heaven in Robotics, Artificial Intelligence, and Virtual Reality*. Oxford/New York: Oxford University Press.

Gherardi, S. .2017. "Has practice theory run out of steam?". *Revue d'anthropologie des connaissances*, vol. 11, 2(2), bk-bu

Goodwin, Brian. 1994. *How the Leopard Changed Its Spots: The Evolution of Complexity*. New York: Charles Scribner's Sons.

Grusin, Richard. 2015. *The Nonhuman Turn*. Minneapolis: University of Minnesota Press.

Hacking, Ian. 1999. *The Social Construction of What?* Cambridge: Harvard University Press.

Hage, Ghassan. 2005. "A not so multi-sited ethnography of a not so imagined community." *Anthropological Theory* 5, no. 4: 463-475.

Hanczyc, Martin M. 2014. "Droplets: Unconventional Protocell Model with Life-Like Dynamics and Room to Grow." *Life* 4: 1038-1049.

Haraway, Donna. 1988. "Situated Knowledges: The Science Question in Feminism and the Privilege of Partial Perspective." *Feminist Studies* 14, no. 3 (Autumn): 575-599.

Haraway, Donna. 1991. *Simians, Cyborgs, and Women: The Reinvention of Nature*

New York: Routledge.

Haraway, Donna. 1994. A game of cat's cradle: Science studies, feminist theory, cultural studies. *Configurations* 2 (1): 59-71.

Haraway, Donna. 2003. *A Companion Species Manifesto: Dogs, People, and Significant Otherness*. Chicago: Prickly Paradigm.

Hasse, Cathrine. 2008. "Postphenomenology: Learning Cultural Perception in Science". *Human Studies* 31 (1):43-61.

Hayles, N. Katherine. 1996. "Narratives of Artiacial Life." in *Future Natural: Nature, Science, Culture*, 146–164. London: Routledge.

Helmreich, Stefan. 1998. "Replicating Reproduction in Artificial Life: Or, the Essence of Life in the Age of Virtual Electronic Reproduction". In S. Franklin and H. Ragone (eds) *Reproducing Reproduction* Philadelphia: University of Pennsylvania Press.

Helmreich, Stefan. 1998. *Silicon Second Nature: Culturing Artificial Life in a Digital World*. Berkeley: University of California Press.

Helmreich, Stefan. 2001. "After Culture: Reflections on the Apparition of Anthropology in Artificial Life, a Science of Simulation." *Cultural Anthropology* 16, no. 4 (November): 612-627.

Helmreich, Stefan. 2009. *Alien Ocean: An Anthropology of Marine Microbiology and the Limits of Life*. Berkeley: University of California Press.

Helmreich, Stefan, and Sophia Roosth. 2010 "Life Forms: A Keyword Entry." *Representations* 112, no. 1: 27–53.

Helmreich, Stefan and Eben Kirksey. 2010. "The Emergence of Multispecies Ethnography." *Cultural anthropology* 25 (4):545–576.

Helmreich, Stefan. 2016. *Sounding the Limits of Life: Essays in the Anthropology of Biology and Beyond*. Princeton: Princeton University Press.

Henare, Amiria, Martin Holbraad and Sari Wastell. 2007. *Thinking Through Things: Theorising Artefacts Ethnographically*. London: Routledge.

Hertzberg, Amanda. 2019. "Life, Love, and Robots: A Conversation." *Felix Online*, May 31, 2019.

<http://felixonline.co.uk/articles/2019-05-31-life-love-and-robots-a-conversation/>

Hoffman, Donald. 2009. "The interface theory of perception." in *Object categorization: Computer and human vision perspectives*, 148–165. Cambridge: Cambridge University Press.

Holland, John H. 1992. *Adaptation in Natural and Artificial Systems*. Cambridge: MIT Press.

Horkheimer, Max and Theodor W. Adorno. 1971. *Dialektik der Aufklärung*. Frankfurt: Fischer Verlag.

Hornyak, Timothy. N. 2006. *Loving the machine: The Art and Science of Japanese Robots*. Tokyo/New York: Kodansha International.

Jay, Martin. 1988. "Scopic regimes of modernity." *Hal Forster, Vision and visuality*, 3–28. Seattle: Bay Press.

Johnston, John. 2008. *The Allure of Machinic Life: Cybernetics, Artificial Life, and the New AI*. Cambridge, London: The MIT Press.

Justin Gillis, 2002. "Scientists Planning to Make New Form of Life." *Washington Post* (November): A01.

Kaplan, Frederic. 2011. "Robotto wa tomodachi ni nareruka: nihonjin to kikai no fusigi na kankei [Can a robot be our friend: The mysterious relationship between the Japanese and robots]". Translated from French to Japanese by Kenji Nishi. [Les Machines Apprivoisées: Comprendre les Robots de Loisir]. Tokyo: NTT Shuppan.

Karatani, Kojin. 2003. *Transcritique: On Kant and Marx*. Cambridge: MIT Press.

Kauffman, Stuart. 1995. *At Home in the Universe: the Search for Laws of Self-Organization and Complexity*. New York: Oxford University Press.

Kauffman, Stuart. 2008. *Reinventing the Sacred: A New View of Science, Reason, and Religion*. New York: Basic Books.

Kay, Lily. 2000. *Who Wrote the Book of Life? A History of the Genetic Code*. Stanford: Stanford University Press.

Keller, Evelyn Fox. 2002. *Making Sense of Life: Explaining Biological Development with Models, Metaphors, and Machines*. Cambridge: Harvard University Press.

Keller, Fox Evelyn. 2009. "What Does Synthetic Biology Have to Do with Biology?" *BioSocieties* 4, no. 2: 291-302.

Kember, Sarah. 2003. *Cyberfeminism and artificial life*. London: Routledge.

Kitano, Naho. 2006. "Roboethics – a Comparative Analysis of Social Acceptance of Robots between the West and Japan". *Paper presented at the Euron Roboethics Atelier*, Genoa, Italy, 27 February–3 March.

Knorr-Cetina, Karin. 1999. *Epistemic Cultures: How the Sciences Make Knowledge*. Cambridge: Harvard University Press.

Knorr-Cetina, Karin. 2004. "How are Global Markets Global? : The Architecture of a Flow World." In *The Sociology of Financial Markets*, 38-61. Oxford: Oxford University Press.

Kohn, Eduardo. 2015. "Anthropology of Ontologies." *Annual Review of Anthropology* 44 (1): 311–327.

Kubik, Ales. 2003. Toward a formalization of emergence. *Artificial Life* 9(1): 41–65.

Kuhn, Thomas S. 1962. *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.

Langton, Christopher G. 1989. Artificial life. In C. G. Langton (Ed.), *Artificial life* (pp. 1–47). Reading, MA: Addison-Wesley.

- Lansing, Stephen J. 2002. "Artificial societies and the social sciences." *Artificial Life* 8 (3), 279–292.
- Lansing, Stephen J. 2003. "Complex Adaptive Systems." *Annual Review of Anthropology* 32: 183-204.
- Laqueur, Thomas. 2008. Form in Ashes. *Representations* 104, no. 1 (Fall): 50-72.
- Latour Bruno, S. Woolgar. 1979. *Laboratory Life: The Construction of Scientific Facts*. Sage Publications.
- Latour, Bruno, and Steve Woolgar. 1986. *Laboratory Life: The Construction of Scientific Facts*. Princeton: Princeton University Press.
- Latour, Bruno. 1987. *Science in Action: How to Follow Scientists and Engineers through Society*. Cambridge, Harvard University Press.
- Latour, Bruno. 1993. *We Have Never Been Modern*. New York: Harvester Wheatsheaf.
- Latour, Bruno. 2005. *Reassembling the Social: An Introduction to Actor-Network Theory*. Oxford: Oxford University Press.
- Law, John, M. Callon. 1994. "The life and death of an aircraft: A network analysis of technical change". In Wiebe E. Bijker and John Law (eds). *Shaping technology/building society: Studies in sociotechnical change*. Cambridge, Massachusetts: MIT Press.
- Leeson, Christina. 2017. *Anthropomorphic Robots on the Move: A Transformative Trajectory from Japan to Danish Healthcare*. PhD Dissertation.
- Lévi-Strauss, Claude. 1995. *Triste Tropiques* London: Penguin Books Ltd.
- Libet, Benjamin. 2004. *Mind time*. Cambridge: Harvard University Press.
- Lock, Margaret and Vinh-Kim Nguyen. 2010. *An Anthropology of Biomedicine*. Hoboken: John Wiley and Sons Ltd.
- Lovelock, James. 2009. *The Vanishing Face of Gaia: A Final Warning*. New York: Basic Books.

Marcus, George. 1995. "Ethnography in/of the world system: The Emergence of Multi-sited ethnography." *Annual Review of Anthropology* 24: 95-117.

Margulis, Lynn and Dorion Sagan. 1995. *What Is Life?* Berkeley: University of California Press.

Massumi, Brian. 1995. "The Autonomy of Affect." *Cultural Critique*, no. 31, The Politics of Systems and Environments, Part II (Autumn): 83-109.

Melody, Jue. 2014. "Proteus and the Digital: Scalar Transformations of Seawater's Materiality in Ocean Animations." *Animation: An Interdisciplinary Journal* 9, no. 2: 245–260.

Meyers, Natasha. 2008. "Molecular Embodiments and the Body-Work of Modeling in Protein Crystallography." *Social Studies of Science* 38, no. 2: 163-199.

Minakata, Kumagusu. 1973. *Minakata Kumagusu zenshū: 9. Shokan*. Tokyo: Heibonsha.

Minakata, Kumagusu. 1951. *Minakata Kumagusu zenshū: 9. Shokan*. Tokyo: Kangensha.

Minakata, Kumagusu. 1971. *Minakata Kumagusu zenshū: 7. Shokan*. Tokyo: Heibonsha.

Miyamoto, Yuto. 2018. "Beyond AI: It's Time to Think About Artificial Life (Again)." *Medium*, November 3, 2018.

<https://medium.com/evertale-english/alternative-machine-7058e71be53>

Monod, Jacques, and François Jacob. 1961. "General Conclusions: Teleonomic Mechanisms in Cellular Metabolism, Growth, and Differentiation." *Cold Spring Harbor Symposia on Quantitative Biology (Cellular Regulatory Mechanisms)* 26: 389–401.

Morgan, Mary, and Margaret Morrison. 1999. *Models as Mediators: Perspectives on Natural and Social Science*. Cambridge: Cambridge University Press.

- Nature* editorial, “Meanings of ‘Life.’” *Nature* 447 (2007): 1031–1032, at 1031.
- Oyama, Susan. 2000. *The Ontogeny of Information, Developmental Systems and Evolution*. Durham: Duke University Press.
- Pfaffenberger, Bryan. 1992. “Social anthropology of technology.” *Annual Review of Anthropology* 21:491–516.
- Peirce, Charles Sanders. 1998. *The Essential Peirce: Selected Philosophical Writings*. Bloomington: Indiana University Press.
- Penny, Simon. 1996. “The Darwin Machine: Artificial Life and Interactive Art,” *New Formations* 29: 65–66.
- Pickering, Andrew. 2010. *The Cybernetic Brain: Sketches of Another Future*. Chicago: University of Chicago Press.
- Povinelli, Elizabeth A. 2016. *Geontologies: A Requiem to Late Liberalism*. Durham: Duke University Press.
- Praet, Istvan. 2015. *Animism and the Question of Life*. London: Routledge.
- Price, Sally. 1989. *Primitive Art in Civilized Places*. Chicago: University Chicago Press.
- Rabinow, Paul. 2011. *The Accompaniment: Assembling the Contemporary*. Chicago: Chicago of University Press.
- Rasmussen, Steen, Liaohai Chen, David Deamer, David C. Krakauer, Norman H. Packard, Peter F. Stadler and Mark A. Bedau. 2004. “Transitions from Nonliving to Living Matter.” *Science* 13 (February).
- Read, Dwight W. 2003. “Emergent properties in small-scale societies.” *Artificial Life* 9(4): 419–434.
- Reid, Roddey, and Sharon Traweek. 2000. *Doing Science + Culture*. New York: Routledge.

- Risan, Lars Christian. 1997. *Artificial Life: A Technoscience Leaving Modernity? An Anthropology of Subjects and Objects*. Oslo: University of Oslo
- Riskin, Jessica. 2003. "The Defecating Duck, or, the Ambiguous Origins of Artificial Life." *Critical Inquiry* 29, no. 4: 599–633.
- Ritzer, George. 2003. *The Globalization of Nothing*. London: Sage.
- Rheinberger, Hans-Jörg. 1997. *Toward a History of Epistemic Things: Synthesizing Proteins in the Test Tube*. Stanford: Stanford University Press.
- Robertson, Jennifer. 2010. "Gendering Humanoid Robots: Robo-Sexism in Japan." *Body and Society* 16 (2):1-36
- Ronald, Edmund M.A., Moshe Sipper, and Mathieu Capcarrère. 1999. "Design, observation, surprise! a test of emergence." *Artificial Life* 5(3): 225–239.
- Roosth, Sophia. 2017. *Synthetic: How Life Got Made*. Chicago: University of Chicago Press.
- Šabanovic, Selma. 2014. "Inventing Japan's 'Robotics Culture': The Repeated Assembly of Science, Technology, and Culture in Social Robotics". *Social Studies of Science*, 44(3), 342–367.
- Schodt, Frederik. L. 1988. *Inside the Robot Kingdom: Japan, Mechatronics, and the coming Robotopia*. Tokyo/New York: Kodansha International.
- Schrödinger, Erwin. 1944. *What Is Life? The Physical Aspect of the Living Cell*. Cambridge: Cambridge University Press.
- Sengers, Phoebe. 1998. *Anti-boxology: Agent design in cultural context*. Ithaca: Computer Science Department and Program in Literary and Cultural Studies, Cornell University.
- Sismondo, Sergio. 1999. "Models, Simulations, and Their Objects." *Science in Context* 12:2: 247-260.
- Sneath, David, Martin Holbraad and Morten Axel Pedersen. 2009. "**Technologies of the Imagination: An Introduction.**" *Ethnos* 74, no. 1: 5-30.

- Snow, C.P. 1959. *The Two Cultures*. Cambridge, UK: Cambridge University Press.
- Sone, Yuji. 2018. "Android Corporeality, Transhuman Performance and the Japanese 'Mind'." *Performance Research* 23:8: 67-73.
- Spencer, Martin. 1970. "Weber on Legitimate Norms and Authority". *The British Journal of Sociology*, 21(2), 123-134.
- Ssorin-Chaikov, Nikolai. 2017. *Two Lenins: A Brief Anthropology of Time*. Chicago: HAU Books.
- Star, Susan Leigh., and James R Griesemer. 1989. "Institutional Ecology, 'Translations' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39." *Social Studies of Science* 19:3 (August): 387-420.
- Steinberg, Philip, and Kimberley Peters. 2015. "Wet Ontologies, Fluid Spaces: Giving Depth to Volume through Oceanic inking." *Environment and Planning D: Society and Space* 33: 247-64.
- Stengers, Isabelle. 2018. "Science Fiction to Science Studies," in *The Cambridge Companion to Literature and Science*, 25-42. Cambridge: Cambridge University Press.
- Strathern, Marilyn. 1992. *After Nature: English Kinship in the Late Twentieth Century*. Cambridge: Cambridge University Press.
- Strathern, Marilyn. 1992. *Reproducing the Future: Anthropology, Kinship, and the New Reproductive Technologies*. New York: Routledge.
- Suchman, Lucy. 2007. *Human-Machine Reconfigurations. Plans and Situated Actions*. Cambridge: Cambridge University Press.
- Suchman, Lucy and Claudia Castañeda. 2014. "Robot Visions." *Social Studies of Science Volume*, 44 (3): 315-341.
- Tambiah, Stanley Jeyaraja. 1990. *Magic, Science, Religion, and the Scope of*

Rationality. Cambridge: Cambridge University Press.

Taussig, Karen-Sue, Klaus Hoeyer and Stefan Helmreich. 2013. "The Anthropology of Potentiality in Biomedicine. An Introduction to Supplement 7." *Current Anthropology* 54, no. S7: S3-S14.

Thacker, Eugene. 2009. "After Life: De Anima and unhuman politics." *Radical Philosophy* 155 (May/June).

Thacker, Eugene. 2010. *After Life*. Chicago: University of Chicago Press.

Thompson, D'Arcy. 1917. *On Growth and Form*. Cambridge: Cambridge University Press.

Thompson, D'Arcy. 1942. *On Growth and Form*. Cambridge: Cambridge University Press.

Thrift, Nigel. 2004. "Movement-space: the changing domain of thinking resulting from the development of new kinds of spatial awareness." *Economy and Society* 33:4 (November): 582-604.

Tsing, Anna. 2015. "Feral Biologies." *Paper for Anthropological Visions of Sustainable Futures*, University College London.

Tsing, Anna. 2015. *The Mushroom at the End of the World: on the Possibility of Life in Capitalist Ruins*. Princeton: Princeton University Press.

Traweek, Sharon. 1988. *Beamtimes and Lifetimes: The World of High Energy Physics*. Cambridge: Harvard University Press.

Traweek, Sharon. 1996. "Unity, Dyads, Triads, Quads, and Complexity: Cultural Choreographies of Science." *Science Wars*: 139-150.

Turkle, Sherry. 2005. *The Second Self: Computers and the Human Spirit*. Cambridge, London: The MIT Press.

Vance, Ashlee. 2016. "Japan Has Birthed a New Life Form: The Drunk Android." *Bloomberg Businessweek*, October 24, 2016. <https://www.bloomberg.com/news/articles/2016-10-24/japan-has-birthed-a-new-life-form-the-drunk-android>

Varela, Francisco, Humberto Maturana, and Ricardo Uribe. 1974. "Autopoiesis: The Organization of Living Systems, Its Characterization and a Model," *BioSystems* 5: 187–196.

Venkatesan, Soumhva, Michael Carrithers, Matei Candea, Karen Sykes and Martin Holbraad. 2010. "Ontology is Just Another Word for Culture": Motion Tabled at the 2008 Meeting of the Group for Debates in Anthropological Theory, University of Manchester.

Vinck, Dominique. 2007. "Back to the Laboratory as a Knowledge Production Space". *Revue d'anthropologie des connaissances* 1(2):160-166.

Viveiros de Castro, Eduardo. 2004. "Perspectival Anthropology and the Method of Controlled Equivocation." *Tipiti Journal of the Society for the Anthropology of Lowland South America* 2 (1): 3–22.

Ward, Mark. 1999. *Virtual organisms: The startling world of artificial life*. New York: Macmillan.

Weber, Max. 1954. *Law in Economy and Society*. Cambridge, Massachusetts, Harvard University Press.

Weaver, Warren. 1947. "Science and complexity". *Facets of systems science*. (Spring): 449–456.

Whitehead, Alfred N. 1920. *The concept of nature: Tanner lectures delivered in Trinity College, November 1919*. Cambridge: Cambridge University Press.

Whitelaw, Mitchell. 2004. *Metacreation: Art and artificial life*. Cambridge: MIT Press.

Wiener, Philip. 1972. *Evolution and the Founders of Pragmatism*. Philadelphia: University of Pennsylvania Press.

Photo Appendix



